Science Library
TN
860
.W93

WORLD PETROLEUM

NEW YORK AND LONDON

JANUARY 1939

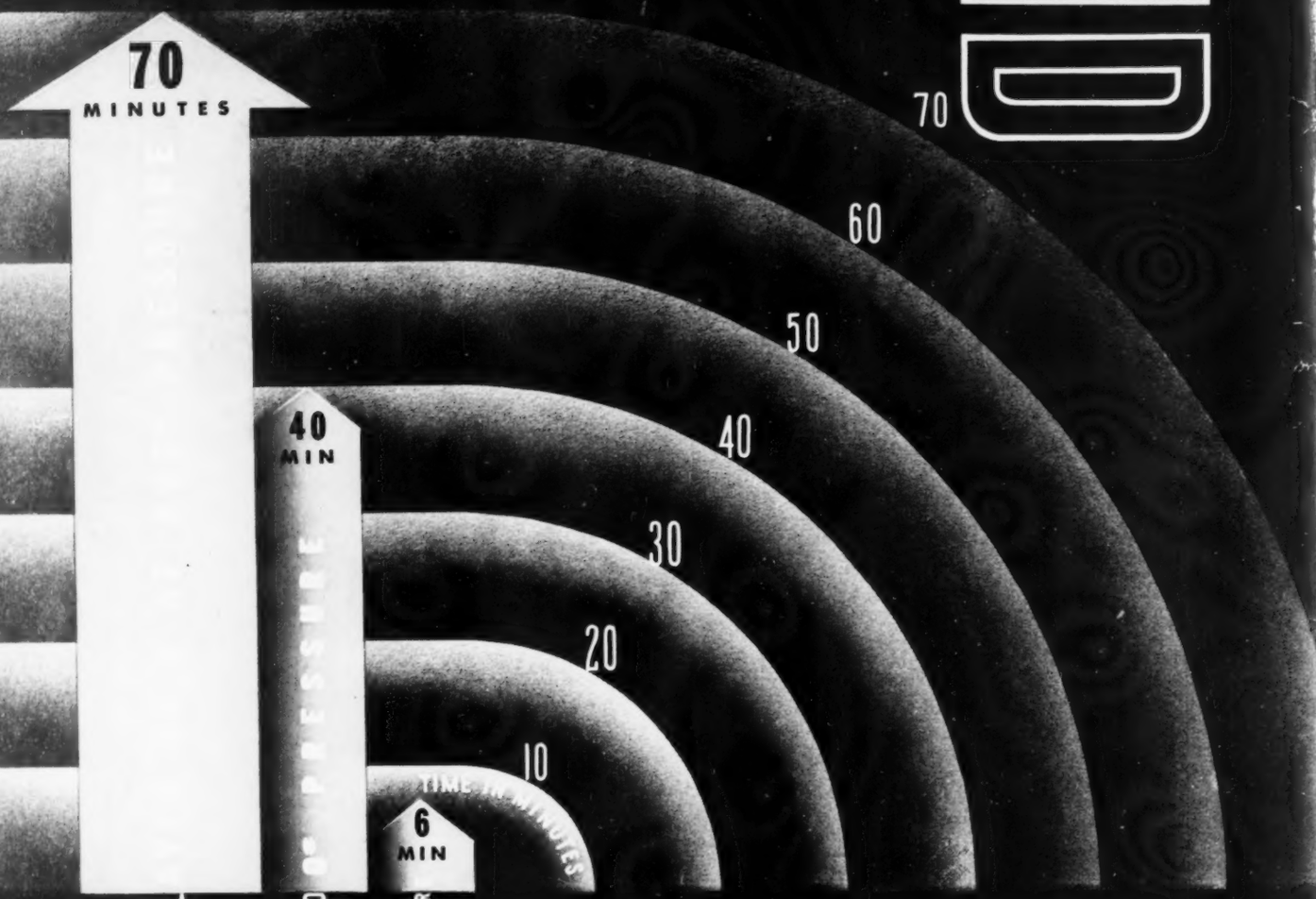
DR. POGUE SURVEYS 1939

COL. THOMPSON DISCUSSES THE COMPACT

GEOLOGY AND ECONOMIC SIGNIFICANCE OF BARBERS HILL

FINANCIAL OUTLOOK FOR 1939

DELAYED ACID



CONTROLLED DELAY OF REACTION

DELAYED ACTION means exactly what its name implies.

Through the use of our Klersol Acid compounds, the rate of reaction is controlled to permit the acid to be pumped to its proper place before it becomes spent.

Thus it eliminates one of the most serious difficulties of acidizing—the danger that the first acid pumped into a formation will become spent before the remainder reaches the formation. It is that condition which causes the spent and useless acid to be forced back into the formation under pressure, with the possibility of creating dams that will later prevent the flow of oil back into the well.

The Howco DELAYED ACID principle may be applied either to ordinary or penetrating acid or to any other of our special acids.

HALLIBURTON OIL WELL CEMENTING CO.

SCIENCE
LIBRARY
TN
860
.W93

WORLD PETROLEUM

RUSSELL PALMER
Publisher

E. W. Mayo
Editor

T. Orchard Lisle
Executive Editor

E. W. Mayo, Jr.
Managing Editor

S. J. Gallay
Advertising Manager

VOLUME 10 **JANUARY . 1939** **NUMBER 1**

WORLD PETROLEUM: Incorporating Petroleum Equipment Exporter

CONTENTS

Commercial Field in Saudi Arabia . . 31

A Look at the Petroleum Industry . . 32

Interstate Compact Aids Conservation . 34

Increasing Profits for 1939 . . . 36

Economic Significance of Barbers Hill . 40

Hydrogenation Plants in Italy . . 56

Russia 59

Gulf Export Prices 61

Foreign Oil Legion 62

World Crude Production 64

Abstracts of World Oil Literature . . 66

CORRESPONDENCE

ADDRESS all correspondence regarding subscription and business matters to the Home Office; 95 River Street, Hoboken, N. J.

Editorial and Advertising offices; 56 West 45th Street, New York, N. Y. London office; 3 Savoy Place, Victoria Embankment, W.C.2.

Los Angeles office; 412 West 6th Street

SUBSCRIPTIONS

ANNUAL subscription to WORLD PETROLEUM is offered at the flat rate of five dollars (U. S.) postpaid to any country in the International Postal Union.

For the convenience of subscribers the publisher will accept payment in any of the following currencies at the fixed rate shown below:

Argentina	16 paper dollars
Canada	5.00 dollars
Colombia	5.55 pesos
France	105 francs
Germany	13 reichsmark
Great Britain	1 guinea
Holland	9 guilders
India	1 guinea
Iran	1 guinea
Iraq	1 guinea
Italy	93 lire
Japan	17 yen
Mexico	18 pesos
Peru	19 sol
Poland	26 zloty
Roumania	675 lei
Russia	6 roubles
Venezuela	19 bolivar

Remittances or drafts should be drawn to the order of the Publisher, WORLD PETROLEUM, payable in New York and London.

Subscriber's name and address should be in Roman capitals on the subscription order.

Official position of subscriber is requested.

Advance notice, if possible, of a change of subscriber's address should be given.

AGENCIES

SINGLE copies of WORLD PETROLEUM are obtainable every month, within the delay imposed by the international mail service, at any of the following agencies:

CABIMAS, VENEZUELA—The German Store
BERLIN, 35, W. GERMANY—Verlag Chemie G.m.b.H. Corneliusstrasse 3.
MARACAIBO, VENEZUELA—High Life Tailors
THE HAGUE—Martinus Nijhoff, Lange Voorhout 9
LONDON—World Petroleum, 3 Savoy Pl., Victoria Embankment, W.C.2, telephone: TEMple Bar 1735
A. C. Hardy, 110 Fenchurch St., E. C. 3
W. H. Smith & Sons, Ltd., Moorgate Met. Station
Willing & Co., Ltd., Moorgate Met. Station
Barker & Howard, 6 Fenchurch Buildings, E. C. 3
NEW YORK—Telephone Hoboken 3-2480 for list of 20 newsstands carrying copies.
PARIS—Librarie Brentano, 37 Avenue de l'Opera
PORT OF SPAIN, TRINIDAD—Davidson & Todd, Ltd., 8 Frederick St.
LOS ANGELES—412 West 6th St., telephone: Mutual 1391

The price of monthly copies is 2 shillings in countries of the British Commonwealth and the equivalent of 50 cents (U. S.) elsewhere.

PARTICULAR NOTICES

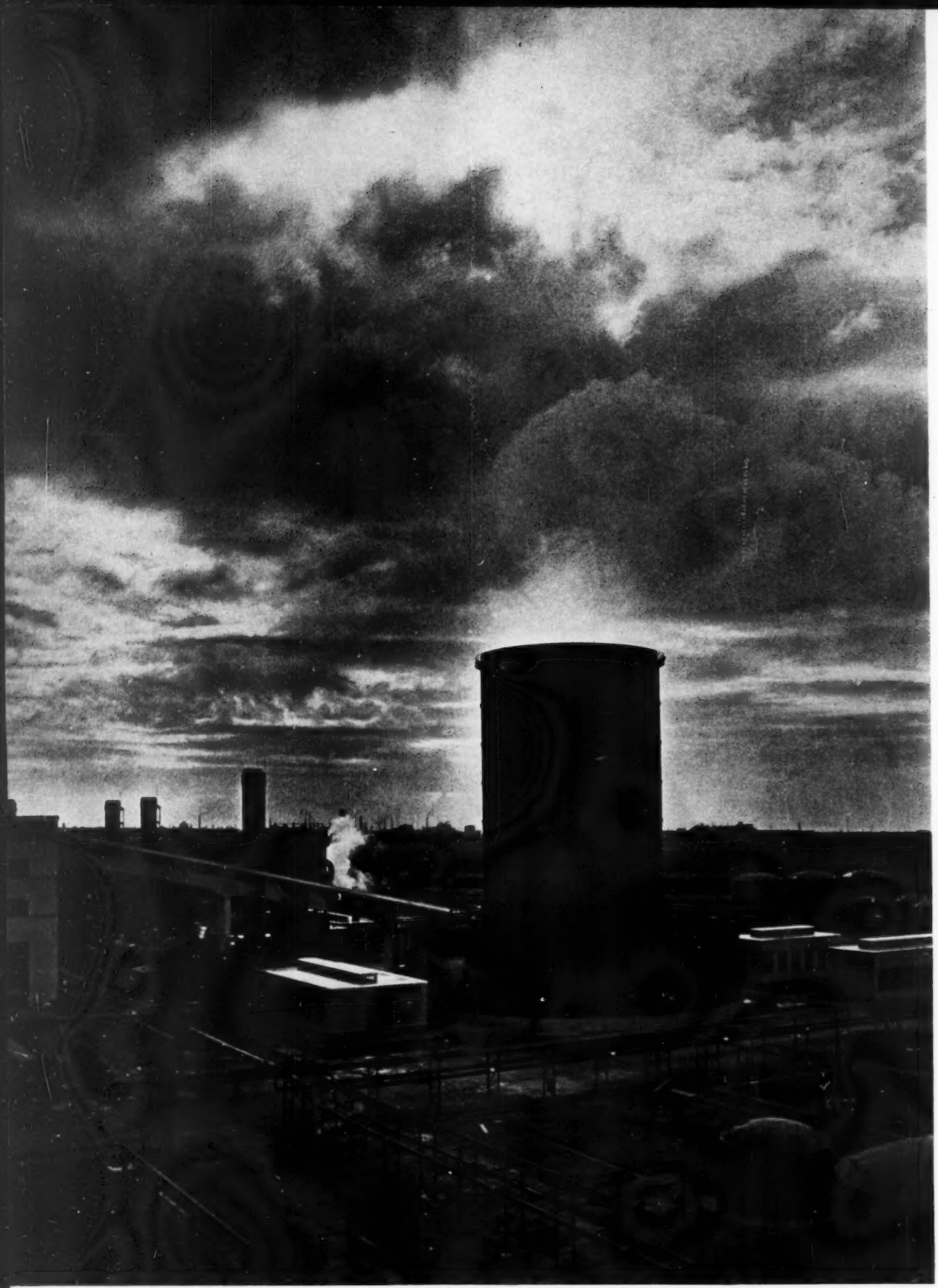
MANUSCRIPTS and photographs submitted to the editor are received only at the owner's risk. Prompt consideration will be given to them.

The Publisher does not necessarily endorse the views expressed by authors of signed articles. In the service of readers he will not hesitate to give publication to signed opinions in direct opposition to his own.

Advertising rates obtainable on request.

COPYRIGHT

COPYRIGHT, 1939, by Russell Palmer. Contents may not be reproduced without permission.



Distillation units, tanks and other prominent features of Italy's refineries are being camouflaged as a protective measure—Livorno hydrogenation plant. On the front cover is shown a striking night view of this plant.

Science Lib.
Geology
3-19-40
40338
v.10

EDITORIAL

PETROLEUM'S OUTLOOK FOR 1939

MOST hopeful augury for the oil industry of the United States in the year now beginning is the widespread recognition, both by state authorities charged with the duty of regulation and by the industry itself, of the necessity of following a sound policy of conservation. Little by little more equitable and scientific methods of proration are being worked out and despite the hampering effect of obsolete legal precedents the problem of avoiding physical waste and assuring optimum production from developed fields is being solved as the authority of the states to regulate production within their own borders and the measures which producers themselves may lawfully adopt become more clearly defined.

End-of-the-year reviews and forecasts emphasize the importance of liquidating excess supplies and avoiding the accumulation of too heavy stocks of motor fuel and other products during the season of low consumption. This involves not only a policy of conservatism in crude production but also the exercise of restraint on the part of refiners in avoiding too heavy runs to stills. In other pages of this issue, Dr. Joseph E. Pogue, eminent petroleum economist, outlines a carefully considered program for the first six months of 1939 which, if followed, will contribute greatly to market stability during the ensuing year.

Two highly constructive developments occurred during December. One of these was the action of the Texas Railroad Commission under the leadership of Col. Ernest O. Thompson in inviting a frank discussion of the situation by representatives of the large integrated companies and leading independents and thereafter adopting a program covering Texas production for the first quarter of the year instead of the usual thirty day period. The other was the success of California producers in bringing about a substantial reduction in the daily crude output of the state and placing it closely in line with Bureau of Mines estimates. This achievement, in view of the fact that California has no proration law and that the situation had been complicated by the bringing in of new flush fields, some of them of the town lot variety, was a notable one. It was not accomplished without strenuous work on the part of leaders in the movement and by the state's oil umpire, J. R. Pemberton, but it would have been impossible of accomplishment except for the co-operation of the great body of small producers. If the limitation of California production to the neighborhood of 600,000 bbl. can be maintained it will gradually bring about a more healthful condition in the Pacific Coast situation and should prevent a threatened debacle of prices.

The success of these efforts and the relatively sound position of the petroleum industry when contrasted with others that are under the complete domination of Washington shows that self regulation is not merely an idle dream and should confirm oil men in their opposition to any further attempts that may be made to extend federal control over their industry.

While caution and restraint are being urged within the United States as a temporary necessity for avoiding widespread destruction of values a survey of the international situation presents a striking contrast. There the order is "full speed ahead." In every quarter of the globe—in South America and the West Indies, in Egypt and the near East, in India, the East Indies and Australasia, and even in parts of Europe where only modest results can be looked for—activity has acquired a faster tempo. Exploratory work, drilling, the provision of transport facilities and the building of refineries, all are being pushed with redoubled

energy in response to the world's demand for greater and greater quantities of petroleum products. The search for oil is carrying the seismograph, the drill and the pipeline into regions scarcely penetrated by white men heretofore. Developments now planned and under way give assurance that 1939 and the years directly following will be marked by the greatest volume of activity ever witnessed in bringing into use the hidden resources of remote parts of the world. Nor is there threat to the stability of the oil industry itself in these activities because many years will be required for full development of the deposits now being located and meanwhile international demands are increasing at an ever accelerating pace.

In the large view, therefore, 1939 should be a year both of exceptional activity and exceptional prosperity in the oil industry. Fortunately men are learning under scientific leadership to apply greater intelligence and skill both in the recovery of oil and in its manufacture into products. The wanton waste that characterized the industry in its earlier years is being steadily diminished and each barrel of oil taken from the earth in this and subsequent years will serve a more useful purpose than ever before.

GHOST TOWNS OF ILLINOIS

IN Charles Dickens's immortal Christmas Carol Old Scrooge was converted to a saner way of life by the intervention of spirits who showed him what his future would be like if he continued on the course he had been pursuing. Perhaps the prospect for the enactment of an effective conservation law in Illinois would be improved if some kindly wraith from the shades of the past could take its legislators on a personally conducted tour of forgotten boom towns which once enjoyed a brief but hectic period of glory because some wildcatter had struck oil in their vicinity.

The list of these phantom towns is a long one, from Pithole and Red Hot in Western Pennsylvania across the mountains and the plains to Kansas, Oklahoma and Texas and on to the Pacific Coast. One would need to travel with the speed of disembodied spirits to visit them all on a single journey. But even a view of one or two as the writer remembers to have seen them in his boyhood—the brush-grown streets, the gaping windows and sagging roofs of erstwhile gaudy hotels and well stocked stores, the silence of death brooding over a spot once teeming with life and activity—would be enough to drive home the consequences of the ruthless exploitation of seemingly exhaustless supplies of rich black gold.

Some of these earlier towns, springing up like mushrooms overnight, waxed, waned and were abandoned in an era when the word conservation was unknown as applied to natural resources. They could not evade their appointed fate, but their ghostly outlines should serve as a powerful reminder to those who are in a position to escape a similar ending.

In mentioning Illinois in this connection there is no intention to imply that this state is less progressive than others. It provides an apt illustration merely because the development of Illinois fields has progressed so rapidly during the past two years that it has taken on something of the nature of a boom and has created a distinct boom atmosphere in certain places.

As Col. Ernest Thompson points out on other pages of this issue time and experience usually are the teachers that bring about the adoption of conservation measures in new areas. Though the hysteria that followed early discoveries is no longer present in modern fields the temperament of the men who find oil is still to push the work of getting it out of the ground with all possible speed. In view of a half century's experience, however, the great advantages of a sane and scientific method of field development in creating a permanent basis of prosperity have been proved so fully that adoption of any other course is short sighted and disastrous.

It is unfortunate that proposals for conservation laws should so often be viewed in a false light by those in whose interest they are projected. Hearing the outcries from Kansas and Oklahoma that Illinois is taking away markets that they formerly supplied the producers of the latter state may feel that they are being asked to surrender an advantage in location for the benefit of others to whom they are nowise beholden. This is a warped view though an understandable one. The interests which a wise conservation law will safeguard are the interests of the state adopting it and of its own citizens. By providing for the maintenance of pressures, the avoidance of waste through too close spacing of wells, and the orderly development of fields in such a way as to insure maximum recovery under sound technical control, it can prolong the prosperity and add to the wealth of the state's own people and can prevent its now busy oil towns from joining the trail of ghost cities of the past.

Sheik Ibn Sa'ud—ruler over most of the Arabian peninsula—and a view showing four of the wells on the Damman dome, eastern Saudi Arabia.

SAUDI ARABIA Attains New Rank as Oilfield

As a result of exploratory work conducted by California Arabian Standard Oil Company, eastern Saudi Arabia has been a producer of oil in a small way since May, 1936. Its total output up to the end of 1937 was roundly 85,000 bbl. and during the first nine months of 1938 it continued at the rate of about 3,500 bbl. monthly. During the final quarter of the year, owing to the bringing in of additional wells, production increased sharply, rising above 150,000 bbl. in November and establishing Damman as potentially one of the world's important oilfields. In view of this enlarged output which ranks it alongside Egypt among producing areas Saudi Arabia will be included separately in World Petroleum's table of monthly world production from this time on in recognition of its arrival at the status of a full fledged and important oilfield.

In addition to the shallow wells first drilled at Damman dome, three wells have been completed to the lower and more prolific horizon below 4,000 ft. which was located when Well No. 2, first brought in at 2,152 ft., was deepened to 4,700 ft. It now is producing high gravity oil from that zone. Two others are flowing from similar levels. Two more are now drilling and within another month it is expected that five strings will be working. Explorations thus far made show that the structure is at least as extensive as that on Bahrein which is now producing at the rate of nearly 25,000 bbl. per day.

Work is being pushed forward rapidly in providing adequate facilities for the handling of Damman crude. A port is being constructed at Ras Tanura, forty-three mi. from Damman dome, and a 10-in. pipeline is being built to connect the two points. Since only shallow draught vessels can dock at Ras Tanura a supplementary 12-in. marine line is being laid from shore to an anchorage at which ocean going tankers can be loaded. When the pipelines and harbor works are completed Saudi Arabian oil and incoming supplies for the field will pass directly through the new port instead of following the more circuitous route via Bahrein as at present. For the time being 5,000 bbl. of crude are being moved daily by means of a six-in. pipeline to Al Khobar and thence by barge to Bahrein. Two Diesel-powered launches convey passengers, mail and express between Bahrein Island and Al Khobar and represent a great improvement over the native dhows which had to be relied upon for transportation in the early stages of the work.

About 100 mi. northwest of Damman, at a location known as Abu Hadriya, the work of proving a new structure is under way. The first well at this site was down 800 ft. on January 1st, 1939. Other promising structures have been located at various points for later development. Geophysical methods are being employed in the work of exploration, seismograph readings being taken from blasts set off in miniature wells drilled for the purpose.

In area Saudi Arabia is larger than the entire state of California. The work completed thus far hardly more than scratches the surface, but enough has been done to prove that it contains fields of first-rate importance. How many of these fields there may be and what figure their ultimate output may reach can be determined only by many years more of active exploration and development.

Setting-in the first valve on the new 10-in. pipeline from Damman to Ras Tanura. About 15 mi. of the total 43 mi. will be coated and buried to prevent corrosion.

A LOOK AT THE P

The old and the new: when the picture directly above was taken in 1865, the industry was just beginning to suffer from extreme fluctuations in supply and demand. Today, when tidewater drilling and rigs such as that pictured opposite are typical, serious efforts are made to analyze supply and demand factors in advance and to follow an economically sound program.

AT THE beginning of 1938 the petroleum industry faced a year of depressed business, with its own momentum not yet damped down to fit the changed conditions indicated by the sharp decline in the business indexes in the latter part of 1937. This situation is revealed in Table 1 which shows the marked alterations in the rate of oil demands that lay ahead as contrasted with the dynamic increases that had previously characterized the situation.

TABLE 1

Percentage Changes in Demand for the First Nine Months of 1936, 1937, and 1938

	1936	1937	1938
Motor fuel, domestic demand	+11.3	+ 9.8	— 0.8
exports	— 6.3	+36.0	+27.2
Total Demand	+ 9.3	+11.2	+ 1.3
All oils, total demand	+10.3	+11.6	— 2.1
FRB Index of Ind. Prod.	+15.7	+13.8	—29.7

The year 1938 was occupied by a slow adjustment on the part of the oil industry to the changed conditions in the general economy, which, however, did not proceed rapidly enough to avoid a weakening price structure culminating in a general break in the crude oil market at the beginning of the fourth quarter. The recession in the price structure, in fact, may be regarded as a deferred adaptation to the altered levels of business and as functionally necessary. We may view the course of the inventory situation for selected oil items in Table 2.

TABLE 2

Changes in Inventories in the Petroleum Industry by Quarters for 1937 and 1938

(In Millions of Barrels)

	Domestic Crude Oil	Motor Fuel	Gas Oil [1]	Fuel Oil [1]	All Oils
1937—1st Q.	+ 9.1	+18.7	—3.3	—2.4	+14.9
2nd Q.	+11.0	— 5.1	+4.1	+3.0	+16.5
3rd Q.	+ 0.3	— 9.6	+5.6	+6.5	+ 9.0
4th Q.	— 4.3	+10.3	—4.4	+1.6	+ 4.3
1938—1st Q.	+ 3.0	+16.0	—4.6	—1.4	+24.2
2nd Q.	—16.1	— 9.9	+5.3	+4.3	— 4.7
3rd Q.	— 9.9	— 9.4	+4.7	+3.4	— 7.6

[1] East of California

At the outset of 1939, the petroleum industry probably faces a year of improved business as compared with the year just brought to a close. The Federal Reserve Board Index of Industrial Production, which averaged 110 in 1937 and 85 in 1938, reached a low of 76 in May of 1938 from which point it recovered to approximately 100 in November. From that figure some slight recession into early 1939 would not be entirely unexpected. For 1939 as a whole it would be hazardous to venture a prediction as to the course of the FRB Index, although an average of 100 might be assumed as a reasonable datum against which to view the petroleum outlook.

On this assumption it is possible to compute the probable domestic demand for motor fuel and to make a guess for exports (for the export market is difficult to appraise on any long-range basis), thus arriving at an approximation of the 1939 requirements for this commodity. The estimate is given in Table 3.

TABLE 3

Estimated Demand for Motor Fuel in 1939

	Domestic		Export		Total	
	Mill. Bbls.	% Change	Mill. Bbls.	% Change	Mill. Bbls.	% Change
1938[1]	519.9	+0.2	46.1	+21.3	566.0	+1.7
1939[2]	549.6	+5.7	40.0	—13.2	589.6	+4.2

[1] Partly estimated
[2] Estimated

With this estimate as a base, we can then determine the probable crude oil demand, but before presenting the computations it is necessary to consider the inventory situation. Motor fuel stocks[1] increased 14,200,000 bbl. in 1937 and 1,000,000 bbl. in 1938[2], ending 1938 at a level of 75,600,000 bbl. Thus the gasoline overproduced in 1937 was not liquidated in 1938 and remains as advanced production available in 1939. Let us assume, therefore, that a minimum of 8,000,000 bbl. of motor fuel should be drawn from storage in 1939 (even more would be preferable). As to crude oil inventories, 16,100,000 bbl. were added to storage in 1937, but over 35,000,000 bbl. were withdrawn in 1938, bringing stocks of domestic refinable crude to around 267,000,000 bbl. at the close of the year. It is probable that the industry could get along with 230,000,000 to 250,000,000 bbl. as a comfortable working stock, but

*The writer is indebted to Dr. Norman D. Fitz Gerald, Department of Petroleum Economics, The Chase National Bank of the City of New York, for assistance in the preparation of the statistical analyses upon which this paper is based.

[1] Finished and natural
[2] Throughout this paper 1938 statistics include estimates for the final part of the period.

PETROLEUM INDUSTRY IN 1939

By Joseph E. Pogue*, Vice President, The Chase National Bank of the City of New York

withdrawals from storage evident in 1938 will doubtless not continue in 1939 to any material extent. The recovery of gasoline will probably be somewhat higher in 1939 than in 1938 and it is doubtless unsafe to count upon the same high level of crude oil exports that characterized 1938. Taking all these factors into consideration, we arrive at a 1939 schedule for runs to stills of 3,252,000 bbl. daily, and a demand for domestic crude oil of 3,443,000 bbl. daily. The results of the calculations are given in Table 4.

TABLE 4

Estimated Runs to Stills and Demand for Domestic Crude Oil in 1939

	1938	1939	% Change
Total daily demand for motor fuel	1,550,000	1,615,000	+4.2
Change in motor fuel stocks	+1,000,000	—8,000,000	....
Gasoline recovery from crude	44.2%	44.5%	....
Crude to stills daily	3,187,000	3,252,000	+2.0
Domestic crude required daily	3,423,000	3,443,000	+0.6
Domestic crude produced daily	3,327,000	.....	....
Change in crude stocks daily	—96,000	.....	....

The view of 1939 as a whole, however, does not present the immediate outlook accurately, because the first part of the year must be occupied by further relative liquidation of products' inventories if a condition of equilibrium is to be attained. It seems improbable that this liquidation can be accomplished in the first quarter and six months may be found to be necessary to work off the surpluses: restrained operations will be necessary to bring this about. An appropriate schedule has been computed for the first two quarters of 1939 and is presented in Table 5.

TABLE 5

Estimated Operating Schedule for First Two Quarters of 1939 Designed to Bring About Reasonable Motor Fuel Equilibrium by June 30

	1939	
	1st Q.	2nd Q.
Motor fuel daily demand, domestic	1,256,000	1,587,000
export	107,000	120,000
Total	1,363,000	1,707,000
Yield from crude	43.5%	44.3%
Production of motor fuel per day	1,496,000	1,586,000
Motor fuel stocks, change in period	+12,000,000	—11,000,000
end of period	87,600,000	76,600,000
year before	90,600,000	80,700,000
Runs to stills per day	3,105,000	3,255,000
Domestic crude required daily	3,277,000	3,470,000

© Cy La Tour

From Table 5 it appears that the carry-over of motor fuel into next April will be too heavy even if runs to stills are held to 3,100,000 bbl. daily throughout the first quarter, hence the second quarter will have to be one of substantial refinery restraint if stocks are to be properly reduced by June 30. It is also apparent that any increase in crude oil production from November levels during the first quarter of 1939 will either support excessive refining operations or else force the raw material into storage.

On the whole, the prospects for earnings in the petroleum industry in 1939 will depend upon the maintenance of restrained operations until the excesses of 1937, only partly liquidated in 1938, are fully compensated for in 1939; and much better results will be attained if this is accomplished during the first half of the year than if deferred until later on.

INTERSTATE COMPACT An Aid to Conservation

By Ernest O. Thompson, ***Chairman***

THROUGH regulatory authorities of the several states and through the Interstate Oil Compact Commission, the oil industry in the past few weeks has achieved a balance of statistics, placing it in a strategically excellent position for the new year.

By consolidating the gains already made, by pushing on with the slow but well-grounded progress, we hope during the coming months to achieve an equally important balance: the balance of understanding the basic aims of state and interstate regulation.

Most often leveled at the Interstate Compact Commission is the criticism that it has and exercises no dictatorial or arbitrary powers. Understanding why this criticism would be made by those not fully aware of the aims and purposes of the commission, we insist that its very strength lies in this quality. We insist, moreover, that the yardstick by which the stature of the compact should be measured is its achievements. We count among its achievements the present position of the oil industry, contrasted on any basis with comparable industries of the United States.

The oil compact commission is a clearing house. Regulators of the industry are state officials. Their primary aim, in theory and in fact, is to conserve the natural resources of their respective states, make those resources mean as much as possible to the ultimate prosperity of those states.

At times the interests of the states, as do the interests of individual men, may seem to conflict. For that reason the compact has been based upon the one foundation concerning which there can be no conflict of interests, the prevention of the irreparable waste of a natural resource.

Officials may differ over the temporary expedient to apply in oil regulation; and they may differ over the temporary objective. They cannot, however, and do not, differ upon the soundness of preventing unwise use of those natural energies by which oil is produced.

We do not contend that the signatories to the compact, as individual regulatory officials in their respective states, have reached the ultimate in preventing wasteful practices. Practices followed for generations cannot be changed overnight. There must be understanding. That is why the "balance of understanding" stands now as a prime objective.

Prevention of physical waste is no abstract principle. Waste prevention is real and concrete. It is accepted by the leaders in the industry.

Ernest O. Thompson, chairman of the Interstate Oil Compact Commsision and of the Railroad Commission of Texas, Austin, Texas.

At the December meeting of the Texas Railroad Commission, men presumed to be, by their position, the wisest in the entire industry were placed on the witness stand. Pointedly we asked each of them:

"Do you consider preserving bottom-hole pressures a sound practice?"

"Do you believe in producing with the most efficient gas-oil ratios?" and other questions of like import.

Invariably the answer was an emphatic affirmative. The questions were not idly asked; the answers not lightly given.

These questions and answers marked progress toward our immediate objective: Achieving the same balance in understanding that we have achieved statistically.

Some there are who are impatient. They would take short cuts. We believe the soundest law and regulatoin is that which is accepted by those regulated, and acceptance can come only through understanding. Acceptance may be slow.

To those who have not followed regulation closely it may have seemed an innovation, perhaps even startling, when Texas promulgated a three-months' proration order effective January 1. As a matter of fact, apparent to all when they examine the record, this order has been in the making for many months. It is an evolution, a logical development.

In the old days the practice was to close down when there was a plethora of oil. When oil was needed it was produced wildly, rapidly. When there was too much the companies quit. It was a chaotic condition, hard on operators, workers, and the public who paid in high prices for wasteful practices.

Ratable production was substituted. The evolution of ratable production has been slow. We have learned as we regulated. Early we learned that to produce in excess of demand was wasteful. So we started studying demand. We asked purchasers how much oil they needed for the coming month, tried to hold production to that figure. The system of nominating needs became firmly entrenched in the overall system of conservation. To check and double check, and because oil production was expanding rapidly, we asked for market demand figures from Washington.

But a monthly forecast, while helpful, proved inadequate. Behind the month-by-month production stood the nation's oil storage as an unknown but vital factor. Above-ground storage is, after a manner, a relic. It was used by producers as an insurance against the time when oil would not readily be available from current production. Each company wrote its own insurance without coordination. Nobody knew what the storage situation was although everybody could guess. More than

two years ago, therefore, the compact commission set out to get the facts about storage. Congress was asked to sanction by appropriation a survey of storage. This survey has proved exceedingly helpful.

Meanwhile we moved in other directions. The objective was still smoother operation. We asked purchasing companies to project their needs over a six-months' period. Nominations forms were changed. For the next succeeding month, purchasers reported firm nominations, the amount of oil the need for which was actually in sight; and anticipated needs for another five months. For considerably more than a year, these figures have been available for study and analysis. We were educating toward the goal of looking further ahead than our noses. In December of 1938, we put into practice this theory. Those who are regulated were ready to try the longer-range policy. Nobody was shocked by the idea of a three-months' forecast of production. They accepted it as sound. And it is sound. It places production on the same quarter—annual basis that is used as a basis for economic operation.

This has been discussed in some detail because I consider it a fundamental example of what we are doing in the compact commission. In a state which has never had oil and its attendant problems, immediate acceptance of the objectives of conservation cannot and should not be expected. Those who regulate and those who are regulated, must first appreciate the fundamentals of conservation. That appreciation cannot be gleaned by reading books and papers. The soundest regulation must be based upon conviction, and conviction comes only through trial-and-error.

If the potentialities of conservation were clearly understood the practices of conservation would be universally adopted. The compact commission aims toward achieving that understanding. We do not aim to achieve it immediately, but in 1939 our objective will be to better it.

Here is the way in which I immediately see the objectives of conservation:

First, establishing an efficient rate of flow for each and every field; that rate of flow at which the largest amount of oil will be naturally produced.

The other points are subsidiary and in relation to the first:

2. Take bottomhole pressures regularly in all fields, and limit flow as indicated by those readings to obtain the optimum production.

3. Don't drill more wells than are necessary to recover that optimum production.

4. Use market demand in conjunction with—and only in conjunction with—the prevention of physical waste.

Apparent in these aims is the importance of sound engineering practices. In fact, proration must be based upon those practices. Moreover regulation is and will be accepted by the general public only when based upon waste prevention, which in turn is based upon engineering.

Perfection must always remain only a goal in human endeavor and the regulatory authorities who meet and discuss their problems under the compact are human. Measured by achievement, it is a vital body through which eventually will be realized the goal of scientifically balanced production achieving the maximum use and benefit of a natural product which product is of first importance in the economy of the nation and the world.

AVOID 1938'S MISTAKES IN 1939

By W. S. Farish, President, Standard Oil Co. (N. J.)

THE PETROLEUM industry finished the year 1938 with only about one-half of the profits it earned the preceding year, and it enters 1939 facing the same obstacles that it failed to surmount a year ago.

In a similar statement a year ago I said refinery runs were so high that gasoline stocks would be up to 93,000,000,000 bbl. by the first of April. Unfortunately, that prediction proved to be correct. The season of heavy gasoline demand opened with an excess inventory of some 12,000,000,000 bbl. and the end of the year finds us with almost no reduction of this excess. Meantime, the industry has gone through the consuming season, selling much of its gasoline at distress prices that failed to return full costs.

That the situation did not become much worse was due to an extraordinary gain in exports. While domestic consumption of crude and products decreased 3.2 percent, exports gained 11.3 percent over 1937.

Crude oil production was maintained at generous levels through the year, but, even so, it failed to meet the demand of refiners who drew upon crude oil inventories to manufacture an additional surplus of finished products.

While no sensationally large discoveries or extensions to petroleum reserves were made during 1938, the development of flush production from earlier discoveries proceeded at such a pace as to force considerable volumes of oil onto the market in several different localities at discounts below the regular posted prices. As a result of this overall performance by the industry, conditions became so bad as finally, in October, to break down the crude oil price structure.

The outlook for 1939 permits a hopeful, if not an optimistic attitude. It is reasonable to expect a modest increase in domestic demand. Exports may fall off but fundamentally, the industry is close to a sound position. There is capacity for overproduction of crude oil from flush areas in several states, but this excess capacity can be maintained only by sacrificing efficiency in production practice and by indulging in flagrant physical waste. Despite all that has been said in favor of conservation, most of us yet fail to realize how large are the losses in ultimate recovery of oil that come about through too rapid depletion of the natural pressures which make wells flow. If no state permitted any of its fields to produce so rapidly as to deplete unduly these pressures, demand and supply would soon be essentially in balance. Yet the known reserves, together with discoveries at the current rate, are sufficient in volume to support a rate of withdrawal by efficient methods adequate to provide for the nation's anticipated demand for crude oil over a period of years.

The important thing for the petroleum industry during the next few months is to refrain from repeating in 1939 the excesses of 1938; that is to say, it should avoid building up burdensome product inventories. More important to the industry's welfare, however, than any other single factor, is the adoption and enforcement uniformly by all producing states of a policy of bonafide conservation, limiting crude oil withdrawals in all flush fields to truly efficient rates.

Gradually Increasing Oil Profits for 1939

By Henry E. Rose

HAVING passed through a year of sharply contracted earnings, the result of a combination of factors, including a low level of general business activity, the American oil industry looks toward 1939 more hopefully. Its optimism is engendered by the hope that certain maladjustments which now exist will have been righted before the new heavy gasoline consuming season is entered next spring.

Influences which exerted pressure on profits, throughout the industry during 1938, were the running of too much crude oil to refineries causing surplus inventories of finished products with a consequent adverse action on price levels, especially for gasoline, the money product.

Gasoline prices, both whosesale and retail, as a matter of fact, late in 1938 hit their lowest in several years and, for the industry generally, were responsible for operating losses in the refining division. As yet there has been no improvement in the price trend, largely because this is normally the season of off-demand when stocks are being built up for the new consuming period.

Whether or not a better price can be realized by next spring, a hope which the industry is counting on, will depend chiefly on the stock level at that time and, in large measure, upon demand. Currently, inventories of finished motor fuel approximate 63,000,000 bbl. and oil economists estimate that minimum economic supplies on March 31, next, should be in the neighborhood of 80,000,000 bbl. During the next three months, hence, additions should be restricted, preferably, to 8,000,000 bbl. although a few million above that would not be considered unmanageable.

Since the increment in the first three months normally has averaged 15,000,000 bbl., it is evident that refiners will have to restrict their runs of crude to stills to avoid a top-heavy position such as existed last year. An indication of the stock trend—whether or not too much is being added to inventories—should be had by mid-February.

Other products for which there was a paucity of demand last year included gas and fuel oil, and lubricants, utilized largely by industry, whose activity throughout most of 1938 was at an extremely low level. Within recent months, however, an improvement in demand for these products has developed although the betterment has not been adequate to be a factor of material importance in 1938 profits of the industry.

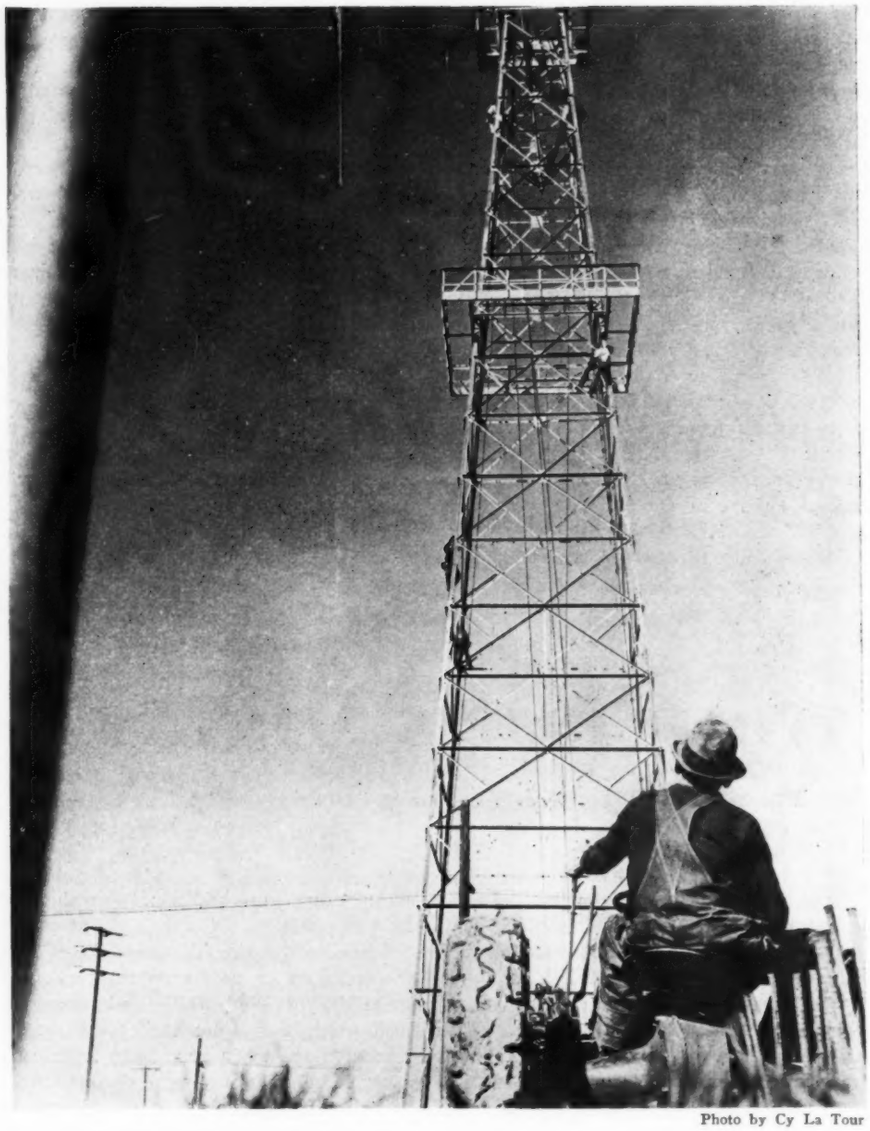


Photo by Cy La Tour

Pacific Coast companies experienced a fairly stable price level during 1938—view in the Wilmington-Long Beach field, California.

Anent refining, it should be mentioned that efforts now are being made to develop plans for its control through the Interstate Oil Compact Commission, a body organized in connection with the administration of the Compact. This latter embraces only six leading producing states (Texas, Oklahoma, New Mexico, Kansas, Colorado and Illinois).

In October, last, Colonel E. O. Thompson, chairman of the Commission, revealed that President Roosevelt, with whom he discussed the matter, indicated his approval of control over refining through the Compact, and would request Congress to sanction such a move. The Compact expires September 1, next, and renewal, on present indications, will be sought.

Many obstacles will have to be surmounted to attain refinery control through the Compact. The present pact members, for example, embrace a minority of the country's refining capacity and legislative bodies of non-member states, which it is intended to invite into it, will have to authorize participation. Moreover, some important producing states such as California, Michigan, Louisiana, Arkansas and

Pennsylvania are not members, and strenuous efforts are being made to seek their participation to make the Compact more influential in preventing overproduction, which has plagued the industry periodically. If those efforts are successful, it is clear that the industry will have achieved a measure of stability long desired.

Despite the fact that production of crude oil has been on a sound basis in recent months, largely because of the efforts of Texas which resorted to a five-day output week, and other leading states which placed a check on output, producers in the mid-continent were forced to take a cut in prices on October 1, averaging 12 percent. The price cut was the result of pressure from the refining division.

Even now, in face of continued underproduction, price cutting is still prevalent and the crude price structure is facing another crisis. A principal reason for this is the practice of some companies to use their storage stocks, because of cost factors, rather than to purchase new output. Inventories above ground, in view of withdrawals, have been reduced to the lowest in almost 17 years, and according to economists, are nearing a level where some companies soon may be forced to replenish their dwindling supplies. In the past year, stocks of crude oil above ground have been reduced by approximately 40,000,000 bbl., or almost 15 percent, to 266,000,000 bbl.

Chiefly because of lower prices for crude oil and refined products, and restrictions on crude output, profits of the American oil industry were reduced from 45 percent to 55 percent in 1938 as against the previous year. For 23 major units, whose shares are listed on leading securities exchanges, it is probable that aggregate profits approximated $325,000,000 last year. During 1937 the profits of these identical companies totaled $607,423,900, a high record.

Solely producing companies, reflecting the stability of price levels for ten months of the year, although they were restricted on production of crude oil, came through with the best showings. During the first nine months of 1938, for example, the profits of these companies showed reductions of from five percent to 23 percent, whereas one, Barnsdall Oil Co., registered a gain of 16 percent in reflection, largely, of a property acquisition late in 1937.

Fully integrated companies east of the Rocky Mountains, in the nine months, came through with declines ranging from 28 percent to 67 percent. Those operating in the mid-continent area of the country, where whosesale gasoline prices were hit hardest, suffered the severest setbacks.

While Pacific Coast companies experienced a fairly stable price level, voluntary restrictions on crude production in the third quarter, and additions to inventories in that period rather than withdrawals as prevailed in 1937, caused recessions of from 23 percent to 28 percent in profits as against the initial nine months of 1937.

The effect of lower prices for refined products in 1938 was mirrored in successively sharper declines in quarterly profits as compared with 1937. For the first three months, the aggregate net income of companies reporting was 31 percent behind; the second quarter ended June 30 was 39.5 percent smaller and the third period ended September 30 was 45.5 percent lower. For the first nine months of 1938, the diminution in profits averaged 42 percent compared with the corresponding period of 1937.

Because crude oil prices were reduced in the southwest in October, and also because there was further weakening in gasoline prices, the final quarter will make the poorest showing for the year. Moreover, many companies, due to price reductions, will be forced to adjust their inventories downward, besides setting up additional reserves.

With the prospect that no sharp improvement in the price level is likely in the early months of this year, for reasons mentioned in the beginning of this article, the indications are that profits will fall below those in the initial quarter of 1938.

From the standpoint of dividend payments to common stockholders, the oil industry made a creditable showing. In fact, related to the drop in profits, the dividend record is decidedly more favorable. While profits for the year are estimated to register a decline of from 45 percent to 55 percent, cash dividend payments on common for the major companies showed only a 24 percent reduction. Furthermore, if there be included the cash equivalent of the stock dividend paid by Standard Oil Co. (N. J.), of three shares for each 200 held (approximating $19,600,000 on the date of declaration), the showing is even more impressive.

Twenty-six companies, including International Petroleum, Imperial Oil Co., Ltd., and Creole Petroleum, all affiliates of Standard Oil Co. (N. J.), disbursed an aggregate of $275,000,000 in cash on their common shares against $361,600,000 in 1937, and $291,624,000 in 1936. Including the cash equivalent of the New Jersey stock dividend, the 1938 payments, hence, would about parallel the 1936 disbursements. Few other industries can match this record for 1938.

Ten companies; namely, Atlantic Refining, Gulf, Sun, International Petroleum, Imperial, Humble, Barnsdall, Creole, Seaboard and Amerada, paid at the same rate per share as in 1937. Sixteen paid smaller rates, as follows: Ohio Oil 20 cents versus $1.00; Standard of California $1.40 versus $2.00; Standard of Indiana $1.00 versus $2.30; Standard of N. J. $1.50 (aside from stock dividend) versus $2.50; Socony-Vacuum 50 cents versus 80 cents; Continental $1.00 versus $1.50; Consolidated 80 cents versus 90 cents; Phillips $2.00 versus $2.75; Shell Union 70 cents versus $1.00; Skelly $1 versus $1.50; Tide Water Associated $1 versus $1.20; Union $1.20 versus $1.40; Mid-Continent 60 cents versus $1.50; Plymouth $1.40 versus $1.65; The Texas Corp. $2.00 versus $2.25 and Lion Oil Refining $1.00 versus $1.50.

Sun Oil Co., which in earlier years paid stock dividends in addition to cash payments, deferred action on the 1938 stock payment until mid-January because of uncertain business conditions.

Cash payments by companies in the Standard Oil group last year approximated $201,000,000, a reduction of about 27 percent from the $273,700,000 disbursed in 1937. Standard Oil Co. (N. J.) maintained its position as the leader, paying out a total in cash of $39,337,150 as compared with $65,549,615 in 1937. The stock dividend paid last month, in addition, has a cash equivalent of $19,600,000.

A number of oil companies last year did some new financing which, for nine majors, entailed $246,076,000. A large part was obtained privately from banks and insurance companies. The new funds, in the main, were to be used for capital expenditures, such as acquisition and development of new crude oil reserves, refinery expansion and improvement, and extension of marketing and transportation facilities. A small part was for the purpose of refunding existing indebtedness or preferred shares.

Standard Oil Co. (N.J.) was the heaviest borrower, selling $85,000,000 of debentures and serial notes. Four companies each borrowed $25,000,000; namely, Phillips Petroleum, Shell Union, Consolidated Oil and Atlantic Refining Co. Continental Oil sold $21,076,000 of debentures, while Ohio Oil borrowed $35,000,000 and Standard Oil of Ohio, $5,000,000.

Several other companies are considering borrowing for capital requirements, while one large unit is studying the possibility of refinancing a currently outstanding debenture issue at a lower cost.

In the accompanying tabulation is shown net income and per share earnings for the first nine months of 1938 of companies issuing interim reports, as well as similar data, together with working capital and other pertinent financial statistics for 23 major American companies and for two companies operating abroad, the Imperial Oil Co., Ltd., and Creole Petroleum Corp., for four years ended December 31, 1937. (Table on pages 38-39.)

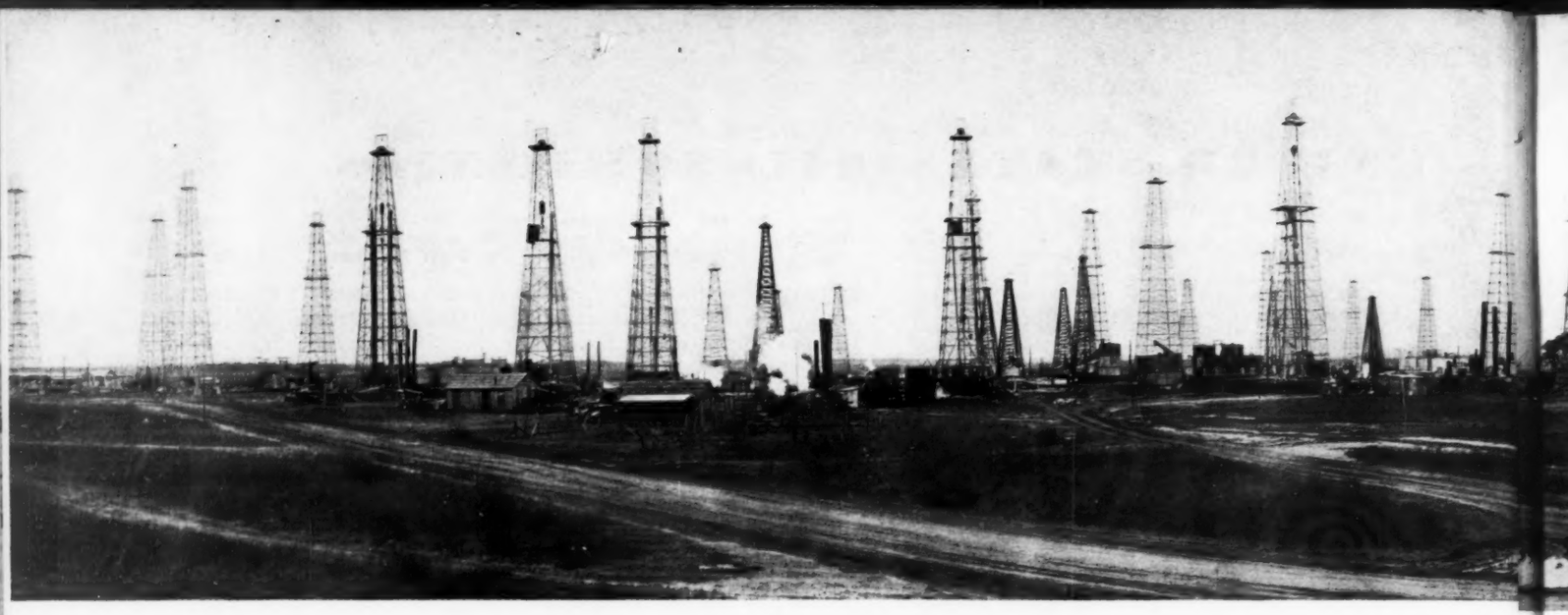
FIVE YEAR FINANCIAL REVIEW

Amerada Corp.	Net Income	Per Share of Com.	Net Working Capital	Net Capital Assets	Funded and/or Long Term Debt	No. of Pref. Shares	No. of Com. Shares	Surplus
(a) 1938	$1,356,886	$1.72						
1937	2,400,028	3.04	$3,714,837	$11,684,811	.....	.....	788,675	$5,055,621
1936	1,983,901	2.52	4,183,364	10,426,074	.....	.....	788,675	4,232,943
1935	1,797,613	2.28	5,008,667	9,227,589	.....	.....	788,675	3,826,392
1934	1,736,420	2.20	5,096,673	8,966,293	.....	.....	788,675	3,606,129
Atlantic Refining Co.								
(a) 1938	3,935,000	1.31						
1937	9,935,045	3.51	22,824,810	134,126,471	508,858	148,000	2,663,999	71,733,501
1936	7,342,197	2.59	34,627,900	113,737,073	522,793	148,000	2,664,000	64,841,504
1935	3,970,598	1.49	36,512,103	111,157,824	14,023,623	.....	2,664,901	65,617,388
1934	5,512,105	2.07	37,960,843	109,739,314	14,024,734	.....	2,664,902	66,791,823
Barnsdall Oil Co.								
(a) 1938	2,602,329	1.15						
1937	1,903,029	.84	1,465,258	11,628,526	3,861,743	.....	2,250,344	6,396,684
1936	2,262,544	1.00	4,611,623	10,044,519	5,000,000	.....	2,247,974	7,471,507
1935	741,136	.34	2,152,780	7,659,141	.....	.....	2,131,090	7,256,270
1934	(d) 1,029,447	...	3,719,365	14,968,355	318,510	.....	2,205,451	9,096,713
Consolidated Oil Corp.								
(b) 1938	4,000,341	.28						
1937	20,809,295	1.44	78,130,681	209,354,872	48,564,969	54,491	13,915,617	190,874,640
1936	16,728,929	1.18	78,118,866	204,171,446	49,720,570	56,592	13,944,886	182,866,672
1935	11,306,904	.74	78,377,440	200,965,255	40,181,938	106,028	13,983,237	180,540,203
1934	553,282	(e)3.43	75,099,378	208,402,801	47,343,015	101,844	13,996,172	175,399,041
Continental Oil Corp.								
(a) 1938	5,793,406	1.23						
1937	13,948,460	2.98	30,395,524	50,970,433	.....	.....	4,662,388	69,133,647
1936	9,612,597	2.05	28,749,999	45,374,654	.....	.....	4,738,593	61,875,373
1935	8,813,561	1.88	31,154,643	39,825,881	.....	.....	4,682,664	56,880,127
1934	4,865,358	1.03	25,390,339	40,647,154	.....	.....	4,738,593	51,780,703
Creole Petroleum Corp.								
1937	11,218,752	1.61	17,073,570	52,162,879	.....	.....	6,974,356	35,638,823
1936	8,596,448	1.23	14,757,203	51,304,681	.....	.....	6,975,383	32,469,427
1935	5,509,067	.79	8,229,979	52,877,364	.....	.....	6,974,356	27,357,909
1934	5,315,254	.76	5,174,439	51,926,430	.....	.....	6,974,356	22,657,566
Gulf Oil Corp.								
1937	31,854,065	3.51	118,361,299	339,864,527	72,913,155	.....	9,076,202	125,071,106
1936	26,356,003	2.90	81,837,311	313,146,546	73,605,813	.....	9,076,202	102,756,263
1935	10,551,720	2.32	96,410,624	288,757,680	87,166,000	.....	4,538,101	199,049,566
1934	2,811,183	.62	97,615,006	283,076,187	91,629,847	.....	4,538,101	189,737,462
Humble Oil & Refining Co.								
1937	46,924,001	5.22	8,245,084	269,905,258	1,648,181	.....	8,987,840	103,172,103
1936	34,183,527	3.80	26,962,743	226,310,687	266,945	.....	8,987,840	74,846,370
1935	23,966,326	2.66	29,002,746	204,138,789	487,610	.....	9,000,000	53,499,275
1934	21,989,954	2.45	31,580,204	193,059,994	6,831,050	.....	8,968,479	38,078,401
Imperial Oil, Ltd.								
1937	26,442,157	.98	64,239,390	39,808,431	.....	.....	26,965,078	73,879,023
1936	25,628,285	.95	71,088,190	43,028,222	.....	.....	26,965,078	81,133,214
1935	25,229,850	.94	72,607,155	53,572,421	.....	.....	26,965,078	89,211,976
1934	25,771,653	.96	69,055,219	58,520,697	.....	.....	26,919,871	97,678,704
Mid-Continent Petroleum Corp.								
(a) 1938	1,507,617	.81						
1937	5,304,877	2.85	18,404,109	39,090,197	.....	.....	1,857,912	42,231,402
1936	4,777,578	2.57	17,771,833	37,841,889	.....	.....	1,857,912	40,519,334
1935	2,417,175	1.31	17,132,369	36,662,598	.....	.....	1,857,912	38,311,091
1934	828,093	.45	15,133,343	36,947,518	.....	.....	1,843,872	36,893,649
1933	(d) 1,766,438	...	14,779,310	50,559,281	.....	.....	1,857,912	13,174,089
Ohio Oil Co.								
(a) 1938	3,935,862	.23				580,943		
1937	11,862,107	1.31	28,777,772	96,387,559	.....	548,077	6,563,377	17,710,658
1936	7,881,571	.70	32,053,658	(k)98,929,683	.....	548,077	6,563,377	18,570,516
1935	5,488,267	.33	32,155,437	(k)93,314,153	.....	548,077	6,563,377	17,915,323
1934	5,411,924	.32	33,740,981	(k)95,599,183	.....	580,943	6,648,052	10,789,515
Phillips Petroleum Co.								
(a) 1938	9,471,956	2.13						
1937	24,113,874	5.42	30,657,681	158,719,012	25,613,233	.....	4,449,052	37,302,764
1936	17,875,489	4.22	23,362,194	146,812,781	14,009,257	.....	4,449,052	29,153,170
1935	13,421,703	3.23	23,450,267	137,258,621	20,945,221	.....	4,132,836	21,954,036
1934	5,757,308	1.38	21,601,235	136,992,626	26,393,309	.....	4,153,235	13,721,113
Pure Oil Co.								
1937	11,403,805	2.15	26,285,254	106,907,568	2,665,760	725,431	3,738,143	46,052,869
1936	7,658,372	1.63	22,195,113	115,413,650	35,194,361	359,617	3,285,120	41,383,155
1935	8,150,026	2.00	24,685,287	110,753,615	38,743,113	309,000	3,038,700	41,728,169
1934	(d) 884,872	...	12,175,503	108,456,105	28,500,000	300,270	3,038,700	34,768,621

UNITED STATES OIL COMPANIES

Seaboard Oil Co.	Net Income	Per Share of Com.	Net Working Capital	Net Capital Assets	Funded and/or Long Term Debt	No. of Pref. Shares	No. of Com. Shares	Surplus
(a) 1938	$1,360,378	$1.08						
1937	2,447,130	1.97	$2,374,122	$6,273,767	.....	.....	1,244,383	$2,343,374
1936	2,485,675	2.00	1,726,067	5,750,047	.....	.....	1,244,383	3,084,451
1935	1,670,847	1.34	2,149,116	5,660,271	.....	.....	1,244,383	1,843,158
1934	1,375,590	1.10	2,323,826	5,523,004	.....	.....	1,244,383	1,416,694
Shell Union Oil Corp.								
(a) 1938	9,364,493	.61						
1937	20,668,880	1.44	54,800,185	269,950,839	61,021,430	341,100	13,070,625	17,350,251
1936	(c)22,494,364	1.57	52,628,694	262,438,076	58,764,000	343,500	13,070,625	11,579,155
1935	6,812,835	.37	41,353,931	261,648,294	50,153,979	388,166	13,070,625	3,419,589
1934	(d) 949,111	...	39,068,934	260,050,464	53,581,227	400,000	13,070,625	(d)18,435,042
Skelly Oil Co.								
(a) 1938	1,973,422	1.69						
1937	6,488,346	6.06	7,823,108	40,868,979	11,734,598	66,300	1,008,549	16,297,582
1936	4,850,314	4.42	5,476,993	38,014,854	10,852,493	66,300	1,008,549	11,647,109
1935	2,585,849	2.16	5,946,672	33,260,799	8,756,859	66,300	1,008,548	9,335,556
1934	713,577	.30	5,841,932	31,527,488	9,615,679	67,000	1,008,548	(d) 2,745,942
Socony-Vacuum Oil Co., Inc.								
(b) 1938	19,000,000	.60						
1937	56,808,264	1.82	223,646,989	457,125,753	128,063,217	.....	31,708,452	189,654,276
1936	42,909,362	1.38	166,291,713	424,296,564	68,378,972	.....	31,151,071	157,766,869
1935	22,525,892	.71	186,858,832	400,094,099	74,326,495	.....	31,708,456	146,736,060
1934	24,121,297	.76	184,148,471	400,204,514	85,014,584	.....	31,154,279	138,588,901
Standard Oil Co. of California								
(a) 1938	23,893,880	1.84						
1937	41,254,778	3.15	61,529,257	449,046,236	494,900	.....	13,102,900	229,298,177
1936	23,310,223	1.78	58,160,244	448,223,894	5,000,000	.....	13,014,754	217,070,827
1935	18,594,330	1.42	62,647,719	445,640,587	5,000,000	.....	13,102,900	212,453,308
1934	18,327,807	1.40	80,120,833	437,191,071	.....	.....	13,102,900	211,733,009
Standard Oil Co. of Indiana								
(b) 1938	17,749,093	1.15						
1937	55,950,784	3.66	156,867,152	371,586,035	8,598,544	.....	15,267,030	284,891,637
1936	46,883,448	3.09	165,331,918	347,502,925	4,094,689	.....	15,196,241	265,367,464
1935	30,179,895	1.98	170,876,326	366,184,636	10,579,963	.....	15,215,677	253,905,946
1934	18,949,680	1.25	182,889,895	175,715,684	8,413,670	.....	15,215,677	226,267,121
Standard Oil Co. (N. J.)								
1937	147,993,147	5.64	434,929,054	1,193,534,803	139,268,806	.....	26,224,767	562,569,681
1936	97,774,583	3.73	432,337,756	1,042,421,175	84,573,564	.....	26,224,767	491,093,355
1935	62,863,192	2.43	425,337,478	1,054,520,041	82,772,730	.....	25,856,081	448,127,942
1934	45,618,960	1.76	407,165,346	1,082,380,163	141,461,816	.....	25,856,081	449,062,205
Standard Oil Co. of Ohio								
1937	3,362,960	3.66	10,625,869	39,874,172	.....	120,000	753,740	18,682,477
1936	4,194,314	4.76	12,764,256	34,730,917	602,026	120,000	753,740	17,112,466
1935	2,690,647	2.77	11,245,428	34,427,880	741,915	120,000	753,740	15,275,632
1934	(d) 1,913,735	...	8,670,081	35,771,654	266,800	120,000	753,740	13,184,984
Sun Oil Co.								
(b) 1938	1,759,686	.63						
1937	9,544,085	4.17	23,813,873	74,090,757	10,330,326	100,000	2,328,330	10,953,754
1936	7,563,554	3.44	20,628,939	70,007,334	6,467,583	100,000	2,156,825	10,053,004
1935	7,100,239	3.45	20,043,466	62,787,994	6,675,681	100,000	2,030,988	9,512,101
1934	6,650,464	3.51	16,250,464	62,545,483	6,500,000	100,000	1,893,982	9,609,319
The Texas Corp.								
(a) 1938	20,554,000	1.89						
1937	54,574,319	5.02	127,058,606	329,648,904	65,667,412	.....	10,875,006	187,358,901
1936	38,260,341	4.10	93,179,802	295,631,713	88,819,129	.....	9,336,739	135,946,875
1935	17,065,037	1.83	125,756,164	257,074,288	93,253,676	.....	9,340,069	103,074,635
1934	5,545,205	.59	119,372,463	266,660,893	103,600,076	.....	9,349,733	103,232,978
Tide Water Associated Oil Co.								
(a) 1938	8,416,905	1.05						
1937	15,801,383	2.09	42,019,706	123,923,854	39,168,798	300,000	6,369,175	28,285,935
1936	10,217,928	1.11	31,990,255	120,062,336	15,925,172	626,221	6,288,512	25,634,444
1935	7,865,701	.73	33,682,301	117,806,258	19,774,335	626,221	5,642,342	21,336,760
1934	5,810,657	.35	41,220,500	113,226,094	2,504,892	636,222	5,631,341	20,620,669
Union Oil Co. of California								
(a) 1938	6,400,000	1.37						
1937	12,061,332	2.58	41,888,136	112,174,792	18,026,500	.....	4,666,270	21,691,244
1936	6,133,398	1.40	36,147,816	107,856,361	20,326,500	.....	4,386,070	15,868,299
1935	5,038,286	1.15	35,545,741	108,543,534	21,526,500	.....	4,386,070	14,120,970
1934	2,902,733	.66	35,976,560	107,956,010	21,489,500	.....	4,386,070	13,914,222

(a) Nine months ended Sept. 30.
(b) Six months ended June 30.
(d) Deficit.
(e) On preferred stock.
(g) On $100 par combined 5½, 6 and 8% preferred
(j) Including good will, appreciation of properties, etc.
(k) Exclusive of good will, patents, etc.



Geology and Economic Significance of BARBERS HILL SALT DOME

By Michel T. Halbouty†

Tenth of a Series of Articles Dealing With the Geology, Reserves and Economy of the More Important Oilfields Throughout the World: First in the Series to Deal With a Piercement Type Salt Dome.

Barbers Hill Salt Dome is located in the northwest part of Chambers County, Texas, approximately 27 miles east of Houston and 18 miles northeast of the town of Goose Creek. The small village of Mont Belvieu is situated on top of the symmetrical dome mound or on the super-dome structure. The dome can easily be reached by many well paved highways leading from Houston from the west, Goose Creek from the south and Dayton from the north.

Figure I is a map showing the immediate area of the dome and a majority of the wells that were drilled on the Barbers Hill dome. This map gives the survey names, as well as the names of the important leases and operating companies. From this map, an idea of the activity at Barbers Hill can be ascertained from observing the locations of the wells.

HISTORY

The Barbers Hill Salt Dome was discovered by means of surface indications which showed a pronounced mound at the surface, gas seeps, paraffin dirt and sulphur water. This dome attracted attention of operators immediately after the Spindletop Dome was discovered as productive of oil in January, 1901. After the Spindletop discovery, it was generally known that surface geological indications were used by Captain Anthony Lucas in determining the location of his famous oil gusher, and as Barbers Hill had a prominent elevation, numerous gas seeps, and paraffin dirt similar to that of Spindletop, the early operators concluded that the Barbers Hill area would also produce oil. In June of 1902, the first well for the exploration of oil at Barbers Hill was drilled on top of the super-dome structure and the well was dry and abandoned in hard caprock at a depth of 934 ft. This well was drilled by Patillo Higgins of Beaumont, Texas, who was considered for many later years, as the foremost independent operator in the early Gulf Coast.

From 1902 to 1906 there were 14 wells drilled on the extreme top of the mound and each of these shallow holes was abandoned as dry in caprock. The depths of these shallow wells ranged from 560 ft. to 1,805 ft. These failures discouraged operators as the general idea at that time was that the dome would not produce oil because of the unfavorable showings in the 14 abandoned wells. The success of operations at the Spindletop Dome in Texas, and the Jennings Dome in Louisiana, in which oil was found on the super-dome structure from depths of 900 to 2,000 ft., led all operators to believe that production in other areas should likewise be present.

Operations at Barbers Hill practically ceased until the year 1916 when geological deduction led operators to explore the near flanks of existing domes. Near flank production was obtained from other domes, and this new idea was carried to Barbers Hill in the hope that the peripheral exploration would be more profitable than the on-top drilling. The Gulf Oil Corporation and the Humble Oil & Refining Company, after drilling three dry holes, obtained the first production at Barbers Hill in their fourth hole, which was located on the Chambers County Agricultural Association land near the southern slope of the hill. The well produced 40 bbl. a day at 1,571 ft. but was soon abandoned after the encroachment of salt water into the well. Very little oil was produced. It was not until 1918 that oil was produced at Barbers Hill in commercial quantities. The United Petroleum Company's Fisher No. 1 was completed in September of that year for 70

†Chief Geologist and Petroleum Engineer, Merit Oil Corp. of Texas, Houston, Tex.

Above—Panorama view of the east flank of Barbers Hill field looking east. Below—Figure 1: Map showing the leases and locations of wells on the Barbers Hill Dome.

bbl. per day of 23 deg. Baume gravity oil and the well was considered as a continuous producer and marked the first successful completion in 16 years of drilling. This production was obtained from the Lower Pliocene sands.

The high price of oil at that time attracted many operators into this new producing area and drilling activity was increased considerably. In the 16 years prior to discovery, there were 28 wells drilled and abandoned and from 1918 to 1920 inclusive, there were 43 wells drilled. Out of the 43 wells drilled after discovery, only 14 produced oil. From 1921 to 1924, 48 more wells were drilled and from this number only 11 were considered producers. The results were very discouraging as from a total of 120 wells drilled, only 21.7 percent were productive. All production was obtained from the southwest side of the dome from an area less than 100 acres, and the total production through 1924 was 780,524 bbl.

Drilling activity at Barbers Hill ceased until 1926 when the Mills Bennett Production Company and the Humphrey Corporation jointly drilled and obtained production from the northwest flank of the dome in the Upper Miocene sands from their A. E. Barber No. 1, which flowed 500 bbl. of 32 deg. Baume gravity oil. This well was considered as the discovery well for the northwest flank of Barbers Hill. Drilling was confined to a very small area near this producing well, and within this area 13 wells were drilled to the *Barber* producing horizon, however, the sand was lenticular, and only six were producers. This production was from 2,200 to 2,400 ft. These two companies, in the latter part of 1926, drilled on the northeast flank of the dome and discovered a better Miocene sand from 4,091 to 4,174 ft. which produced oil, and the well, Kirby B-2, marked the discovery of production on the north-

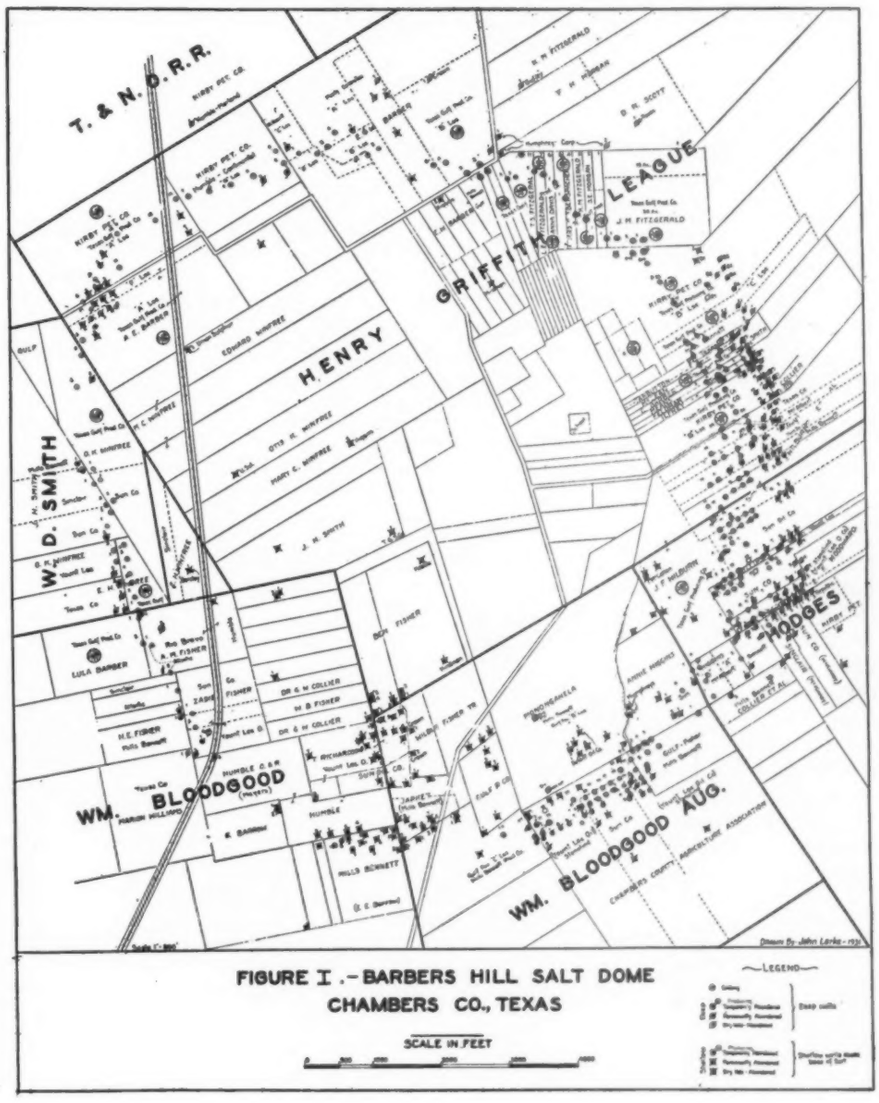


FIGURE I.—BARBERS HILL SALT DOME
CHAMBERS CO., TEXAS

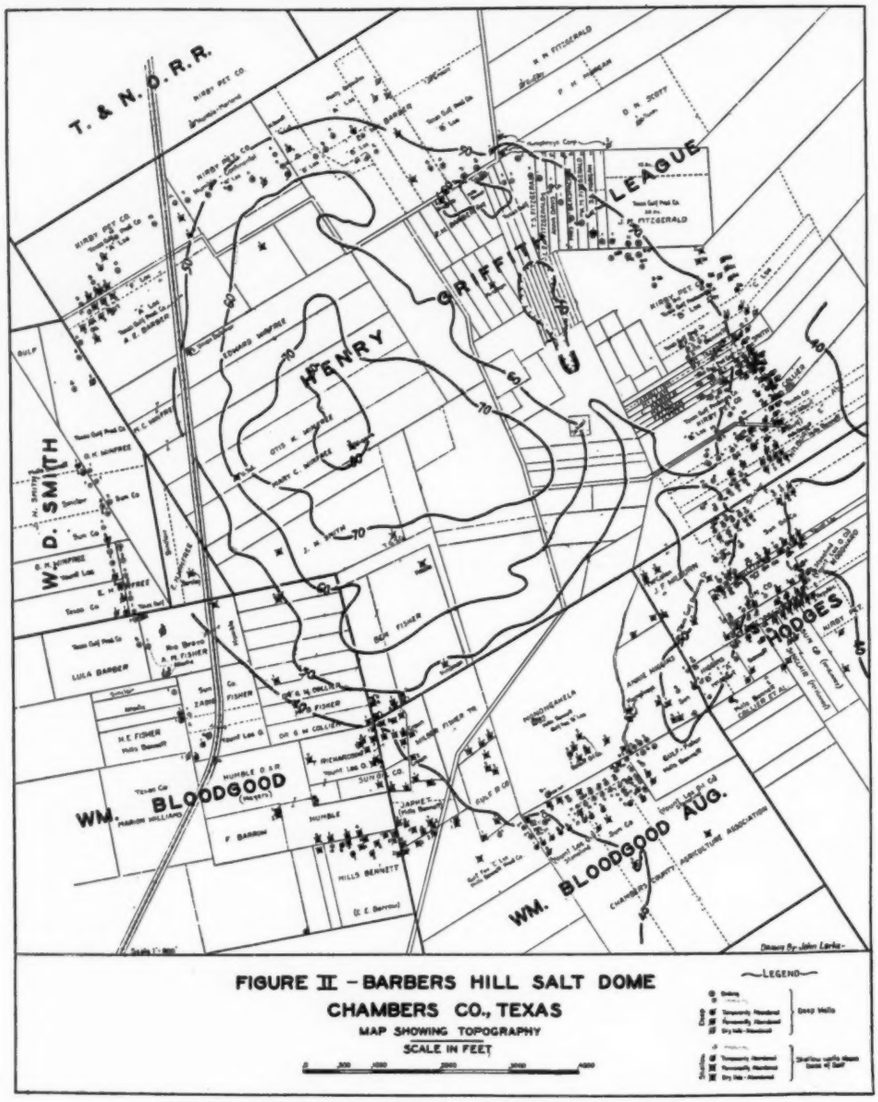


Figure II: Topographic map; 10 ft. contour intervals.

east flank of Barbers Hill. Thirty-six wells were drilled in the vicinity of the Kirby B-2 well in an area 1,600 ft. long and 200 to 300 ft. wide and the majority of these wells were good producers. During this drilling campaign the *Discorbis* and *Heterostegina* zones of Middle Oligocene Age were found to contain sand bodies, which totally established production from four separate geological horizons: the Lower Pliocene, Miocene, *Discorbis* zone and *Heterostegina* zone. Depths of the Oligocene wells ranged from 4,900 to 5,300 ft.

In the year 1929, the Republic Production Company discovered Oligocene production on the southeast flank in their Kirby Petroleum Company No. 1, from sand at a total depth of 5,194 ft., which flowed 3,420 bbl. of oil per day. Also in 1929, the Yount-Lee Oil Company discovered Oligocene production on the south flank of the dome from a sand at a total depth of 5,318 ft.

Success of obtaining production on these flanks at Barbers Hill encouraged drilling and a large number of producing wells were completed. Out of the 77 wells drilled to the deep sands on these flanks, 71 were producers. Drilling reached its peak in 1930, 1931 and 1932, then gradually declined. At the present time, drilling is still conducted on a small scale. Only three rigs are active in the field.

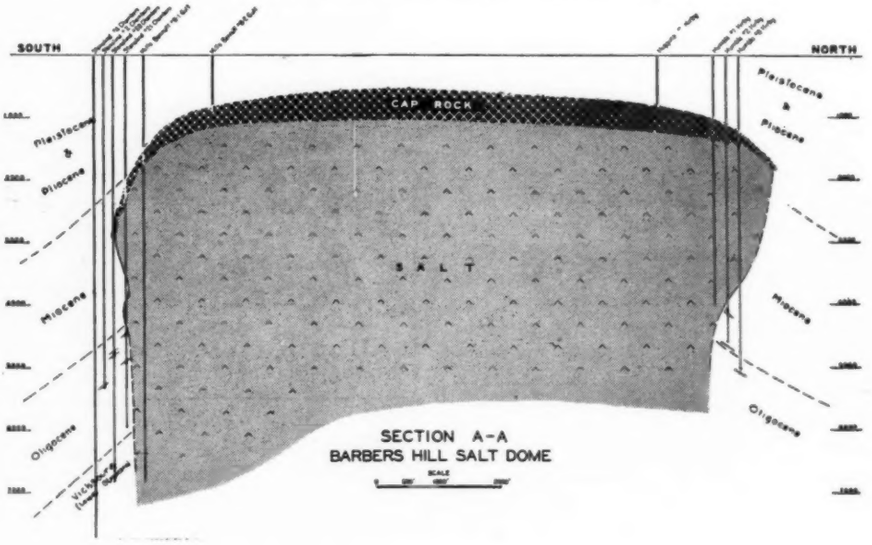
In this history it is proper to state that the most important geological feature which was found at Barbers Hill is the presence of oil sands under the caprock and salt overhangs. The presence of the overhang proper, and also production underneath it, was first established in the Humphrey Corporation's Ilfrey No. 2, which was drilled on the east flank of the dome through 878 ft. of salt, thence into sedimentary formation to the 5,100 ft. sand, and which produced 1,062 bbl. a day. Up to the present time 170 wells have been drilled through the overhang and 165 have been completed as producers.

Through October, 1938, 64,015,498 bbl. of oil have been produced at Barbers Hill. Some idea of the development of the field can be gained from Table No. I which shows the annual prodution since the completion of the first producer in 1918.

There are five pipelines serving the field: Humble Pipe Line Company's eight-inch, Texas Pipe Line Company's six-inch, Sun Pipe Line Company's six-inch, Sinclair-Prairie Pipe Line Company's four-inch, and the Atlantic Pipe Line Company's six-inch.

The principal leaseholders are the Texas Gulf Producing Company, Mills Bennett Production Company, Humble Oil & Refining Company, Gulf Oil Corporation,

Section A-A. North-South cross section from Figure V on page 45.



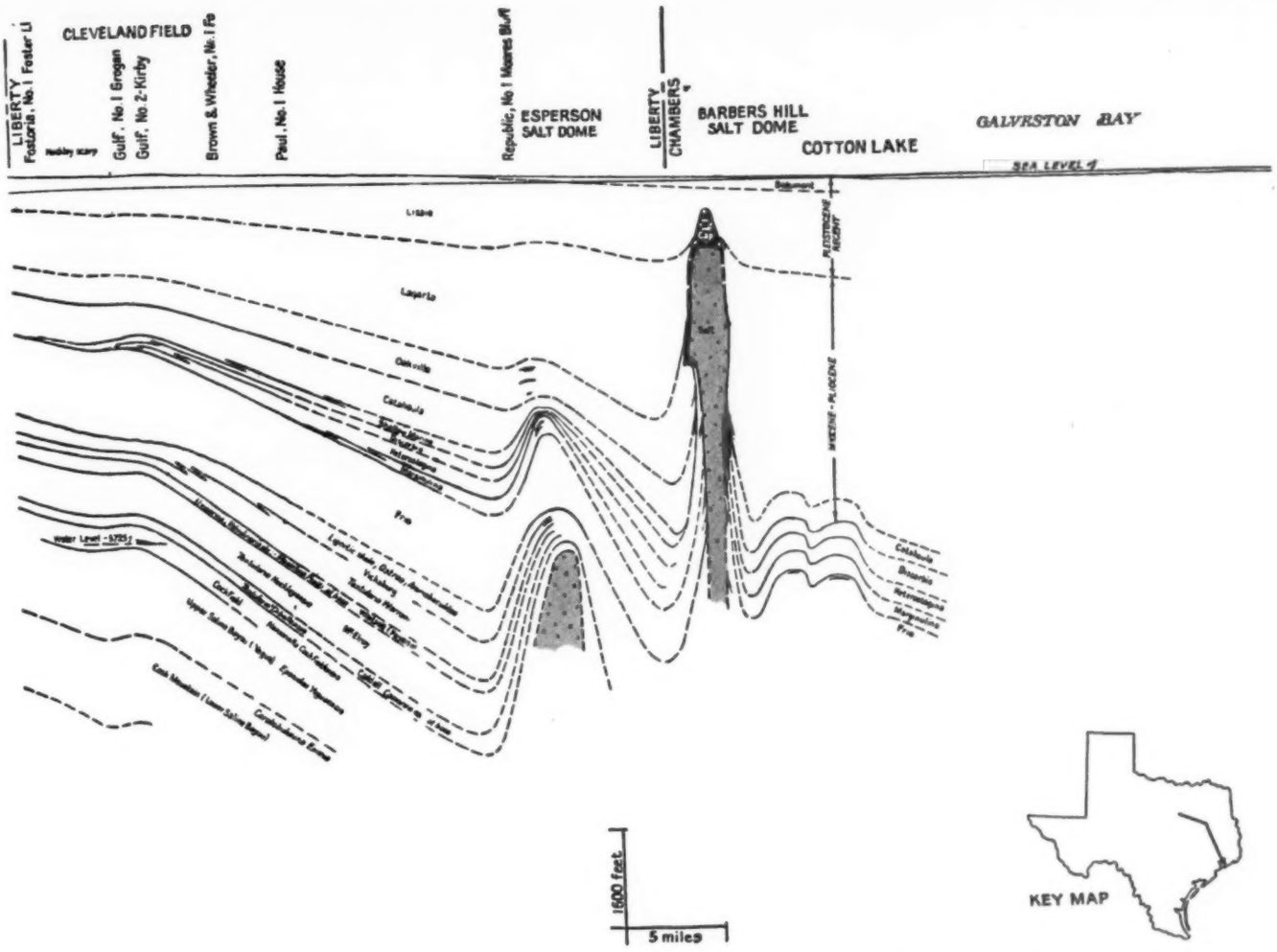


Figure III: Geologic section showing the relationship of Barbers Hill Salt Dome to the Esperson Salt Dome and the geologic distribution of the formations (after Wallace C. Thompson).

TABLE I

Barbers Hill Annual Production Since Discovery

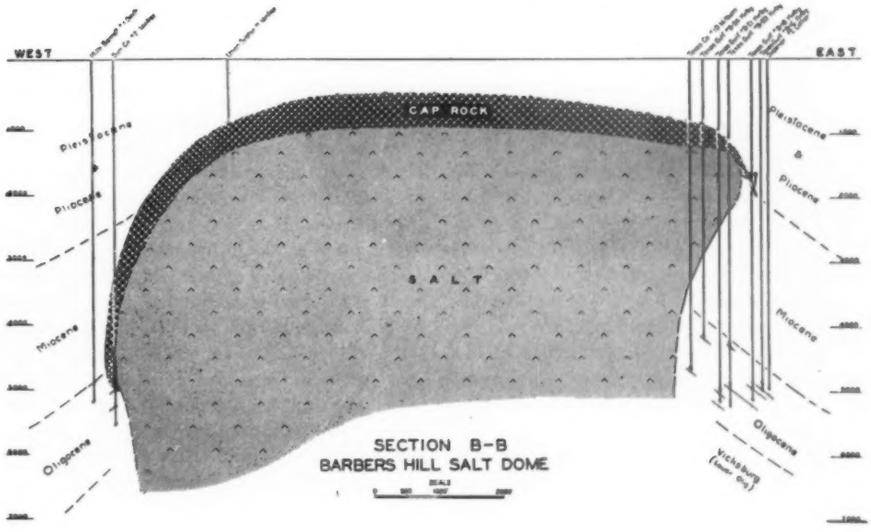
YEAR	BARRELS
1918	20,000
1919	169,415
1920	136,367
1921	49,885
1922	236,185
1923	172,660
1924	72,437
1925	46,718
1926	146,312
1927	68,575
1928	322,950
1929	4,552,000
1930	7,441,000
1931	7,651,000
1932	7,320,000
1933	8,082,000
1934	6,820,000
1935	6,765,000
1936	5,493,000
1937	4,399,000
1938 (To November 1)	4,051,000
Total	64,015,498

Stanolind Oil & Gas Company, Sun Oil Company, Sinclair Oil Company, The Texas Company, Republic Oil Refining Company, Atlantic Refining Company, McAlbert Oil Company, Superior Oil Company, D. B. McDaniel and the Rio Bravo Oil Company.

PHYSIOGRAPHY

Barbers Hill Salt Dome is located in a northwest direction from the coast line of

Section B-B. East-West cross section from Figure V.



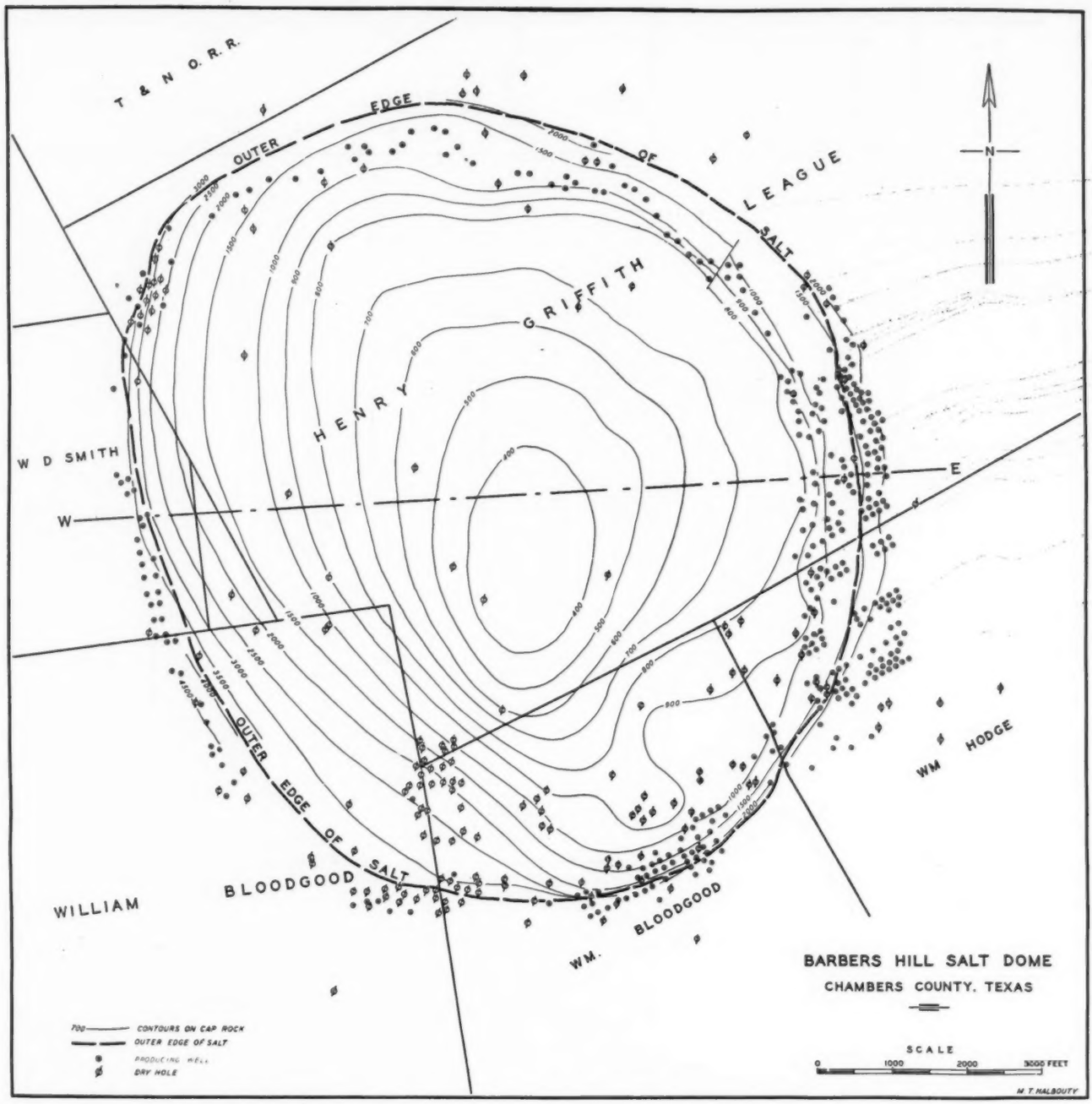


Figure IV: Map showing the contours based on top of the caprock and also the outer edge of the salt.

the Gulf of Mexico and is approximately 34 miles inland from that body of water. The topography of Barbers Hill is that of a mound rising out of the general lowland area, and the elevation of this mound is 86 ft. above sea level and 45 ft. above the surrounding prairies. The mound is irregular in shape with a general radial drainage to the lowlands. The slopes on the northwest, west, and southwest flanks are steeper than those of the eastern side. Numerous gullies outline the flanks of the mound caused by continuous active erosion. The largest of these gullies is on the south flank of the mound and marked evidence of rill drainage is present on the west flank. The east flank of the mound is more regular than any other flank as the erosional features are not as rugged, and a gentle slope toward the east plains is very evident.

Numerous pimple mounds dot the plains and the hill proper. These pimples or gas mounds are found only on the sandy soil that occurs on top of the hill and off the flanks. The area is practically treeless except for small woods on the west flank.

Figure II is a map showing the topography of the dome. The contours are based on 10 ft. intervals. It is to be noted that there is a gradual rise towards the center of the map which marks the center of the super dome structure.

SURFACE GEOLOGY

The Beaumont Clays of Pleistocene Age are exposed at the surface at Barbers Hill. The soil on the hill is very sandy, whereas the soil in the lowlands is clayey. The Beaumont clays, as found on and around the dome, are buff to grayish-black in color and become very sticky when wet. In a study of an aerial photo-mosaic of the

Barbers Hill Dome. Barton[2] gives a very interesting explanation of the evidence and presence of an ancient stream which was a distributary of the Beaumont Trinity River. Because of Barton's thorough explanation of this ancient stream, his report of its existence is herein reprinted in full:

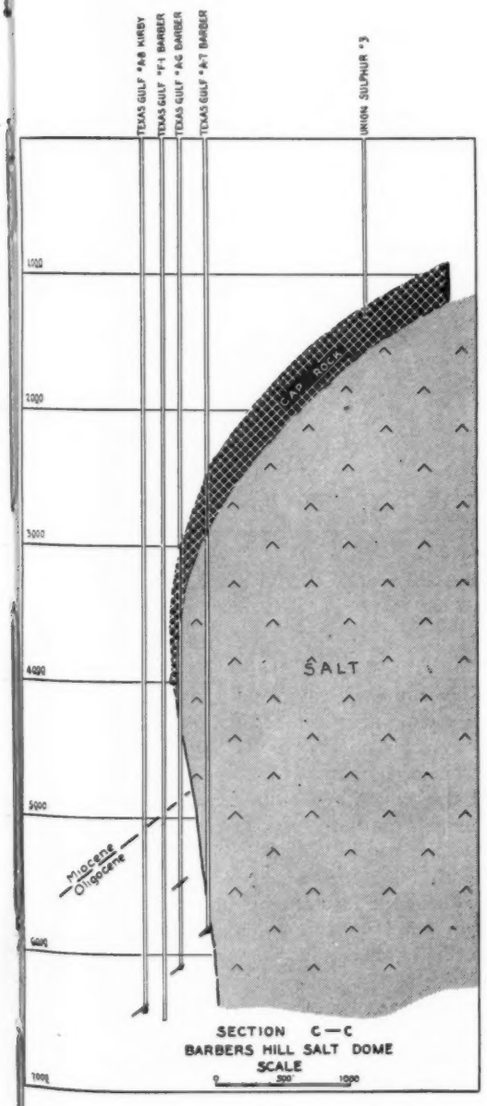
"The age of formation of the topographic mound at Barbers Hill is given by the relations of the ancient stream and the mound.

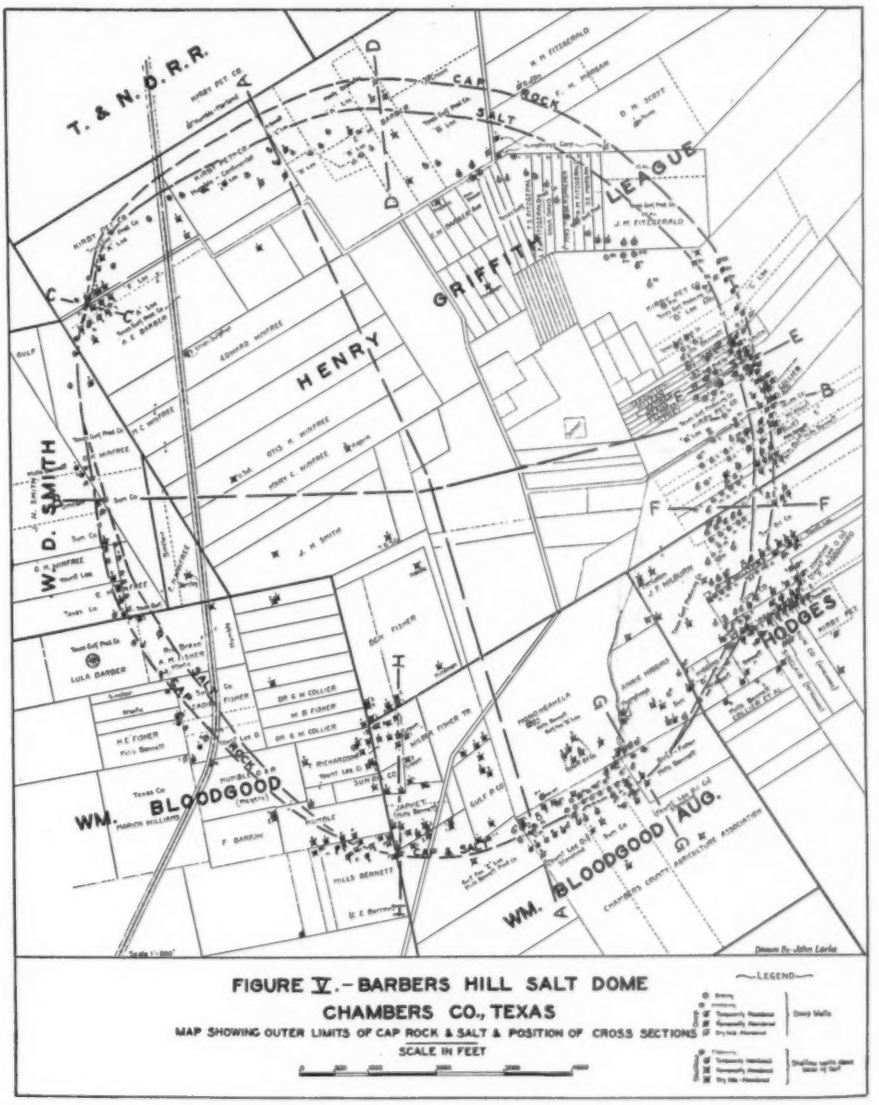
"1. When the stream first established its course across this area, necessarily no mound could have been present.

"2. First uplift of the mound came when the stream was still flowing but was decadent: (a) the meandering course extends from the mound upstream for several miles; and downstream from the mound for many miles, well beyond the limits of this mosaic, the course is only faintly curvilinear; (b) incipient uplift of the mound, therefore, incipiently dammed the stream and caused it to meander upstream from the mound; (c) if the stream had been dammed in its active days, while it was building this broad distributary ridge, it would have jumped one levee or the other and established some other course in avoidance of the mound, or it would have maintained its channel across the mound; but (d) it did neither; therefore, the upwarping of the mound may be presumed to have come after the stream had become decadent.

"3. The uplift furthermore may be dated back to the latter part of the Beaumont. General experience with the Beaumont deltaic deposits shows that the stream channels of some of the systems are well preserved, as for example, those of Galveston County; but that the channels of other systems, as for example, those of Harris County, have wholly disappeared. The former streams according to the writer's interpretation are to be referred to very late Beaumont; and the latter to earlier although not necessarily early Beaumont. The channel of the Beaumont stream in the mosaic has the appearance of belonging to a stream younger than the Harris County distributary system and older than the Galveston County system.

"4. The upwarping of the Barbers Hill mound, therefore, started in the latter part of Beaumont time but well before the end."





Left—Section C-C from Figure V (above) which shows the positions of cross section A-A through H-H.

Figure X is a photo-mosaic showing the dome located in the center and the uplifted sand of the mound clearly outlining the hill. The rill drainage is located in the northwest flank of the mound. The old stream channel which is described by Barton is seen in the north center of the mosaic or immediately north of the mound.

STRATIGRAPHY

The Beaumont clays of Pleistocene age at Barbers Hill range in thickness from 25 to 150 ft. and on the dome proper, the clays

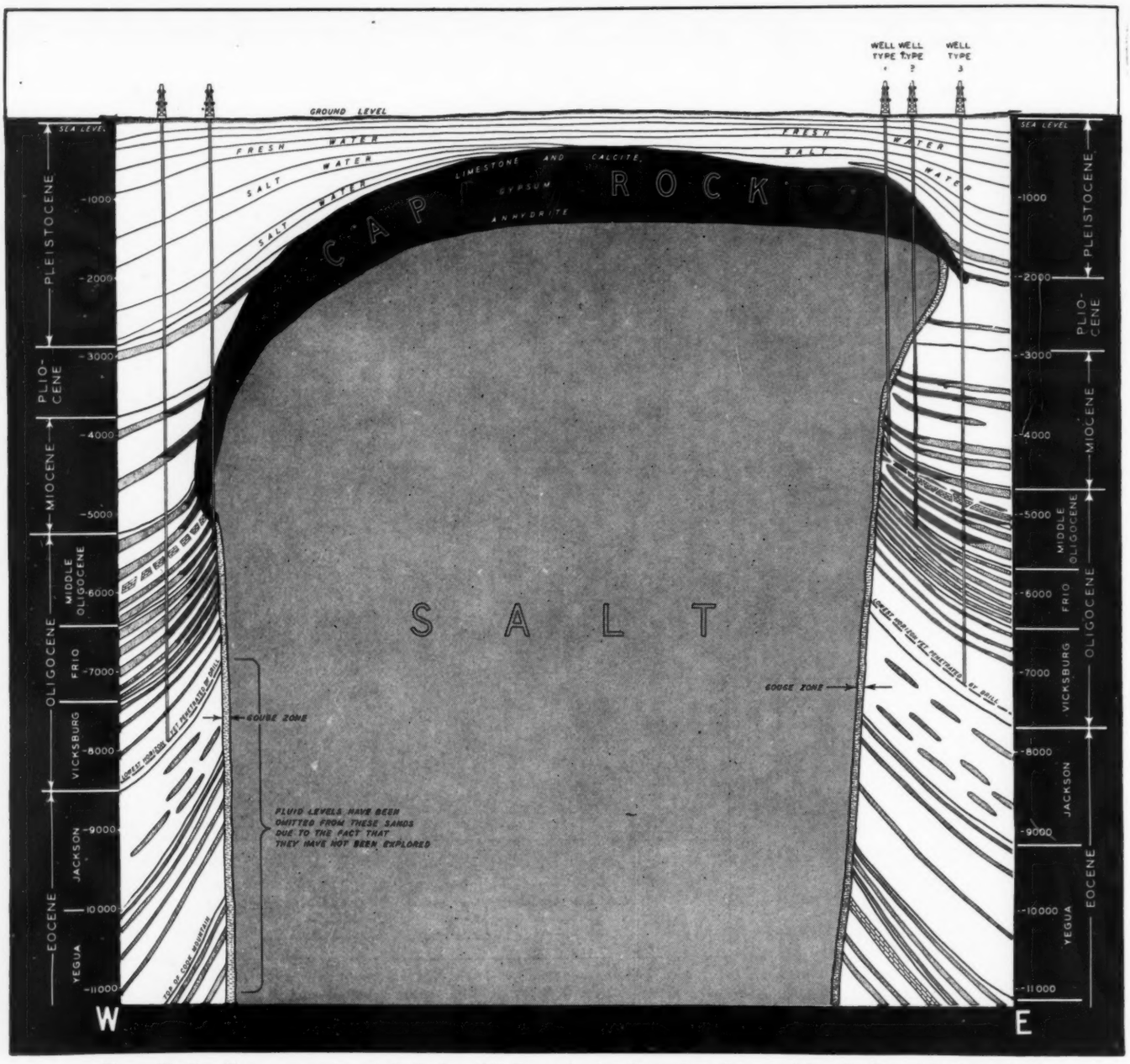


Figure V1: East-West cross section of the Barbers Hill Dome showing the sand conditions and how the dips of the formations against the dome increase as depth is obtained.

are compact; on the outer edges and on the flanks, the clays are soft and loamy. The Beaumont clays are very sticky and are considered to be fine mud making material. They were used in early drilling as a base for the drilling muds.

The Lissie formation, which is also Pleistocene in age, underlies the Beaumont clays and its appearance is definitely marked by the first sand break found below the Beaumont clays. The Lissie formation is characterized by non-marine gray sands and gravel with some gray, pink and green calcareous clays. The large bodies of sands were intermingled with sandy shales and contain numerous boulders. All of the sands are fresh water and in that area the Lissie formation is considered as being a good reservoir for fresh water wells. On the super dome structure the Lissie formation is from 600 to 700 ft. thick and increases in thickness towards the flank to a maximum of 1200 ft.

The Pliocene formation is identified at Barbers Hill by non-marine bluish green shales and medium grained sands. Occasional layers of hard sandstones and limestones are found. The base of the Pliocene is far more calcareous than the upper zones. In the majority of the wells drilled into or through this formation, the base of the formation was found to contain a layer of calcareous sandstone, which was very prominent in the field. This formation is from 800 to 1,300 ft. thick.

The upper part of the Miocene formation at Barbers Hill is composed of non-marine greenish gray and pink gumbo and fine to medium grained sands. Reworked fossils are abundant in this zone. The lower part of the Miocene formation is non-marine with light grayish green and purple shales and medium grained sands. A few shallow water marine beds are also present. The Miocene formation at Barbers Hill is from 1,500 to 2,200 ft. thick.

Underneath the Miocene formation is the Middle Oligocene formation which is di-

vided into three zones. The first of these zones, which lies directly underneath the Miocene beds, is the *Discorbis Zone* which is composed of marine fossiliferous gray shales and medium grained sands. The *Discorbis Zone* is identified by the appearance of the *Discorbis* cf. D. *villardeboana* and its associated fauna and the zone is irregular in thickness, ranging from 200 to 350 ft. thick. This thickness is determined and controlled by the dips of the formation against the dome.

The second zone in the Middle Oligocene formation and which is encountered at Barbers Hill is the *Heterostegina Zone* which lies underneath the *Discorbis* beds. The *Heterostegina Zone* is definitely characterized at Barbers Hill by the presence of a 40 to 70 ft. layer of hard fossiliferous limestone and which is easily correlated in the field. Associated with this limestone and which makes up the rest of the horizon are fossiliferous gray shales and clean medium gray sands. The sands lie near the base of the formation. The *Heterostegina Zone* is characterized by the *Heterostegina antillea foraminifera* and its associated fauna. The zone is from 175 to 250 ft. thick.

The *Marginulina Zone* is the lower zone in the Middle Oligocene formation and lies underneath the *Heterostegina Zone* beds. This zone is characterized by medium to coarse grained sands with some dark chert, and gray and greenish gray shales. The zone is characterized by an abundance of *Marginulina foraminifera* definitely marked by *Marginulina* cf. M. *philippinensis*. The *Marginulina Zone* is from 200 to 350 ft. thick at Barbers Hill.

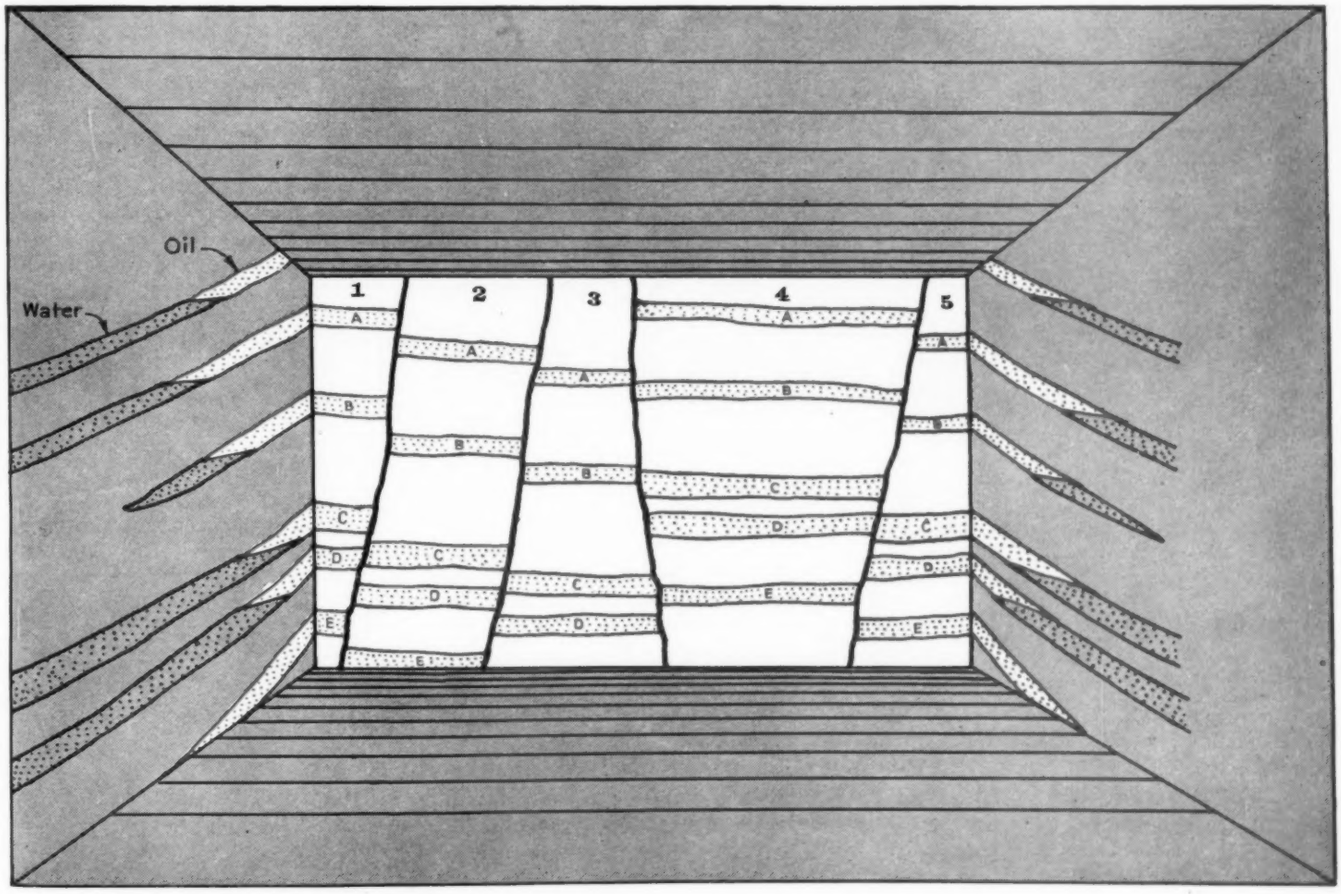
Underneath the *Marginulina Zone* is the Frio horizon which is the upper member of the Lower Oligocene formation. The Frio at Barbers Hill is dominantly a sandy formation composed of medium to coarse sands and gray to brown non-fossiliferous shales. Shales, as well as sands, contain an occasional thin streak of lignite. The thickness of the Frio horizon at Barbers Hill is from 800 to 1,000 ft.

Underneath the Frio horizon is the lower member of the Lower Oligocene formation and which is known as the *Vicksburg* horizon. The *Vicksburg* consists of light greenish gray to dark green calcareous bentonitic shales which are marine and contain an abundance of *Vicksburg foraminifera*. Few thin bodies of fine to medium grained sands are found in the *Vicksburg*, however, the majority of the sands found and cored are very shaly. The lowest horizon yet penetrated by the drill is in the lower part of the *Vicksburg*. This particular section in the *Vicksburg* consists dominantly of shales. The sands that are present in the *Vicksburg* occur in the middle and upper parts. The thickness of the *Vicksburg* horizon at Barbers Hill is estimated to be from 1,100 ft. to 1,600 ft.

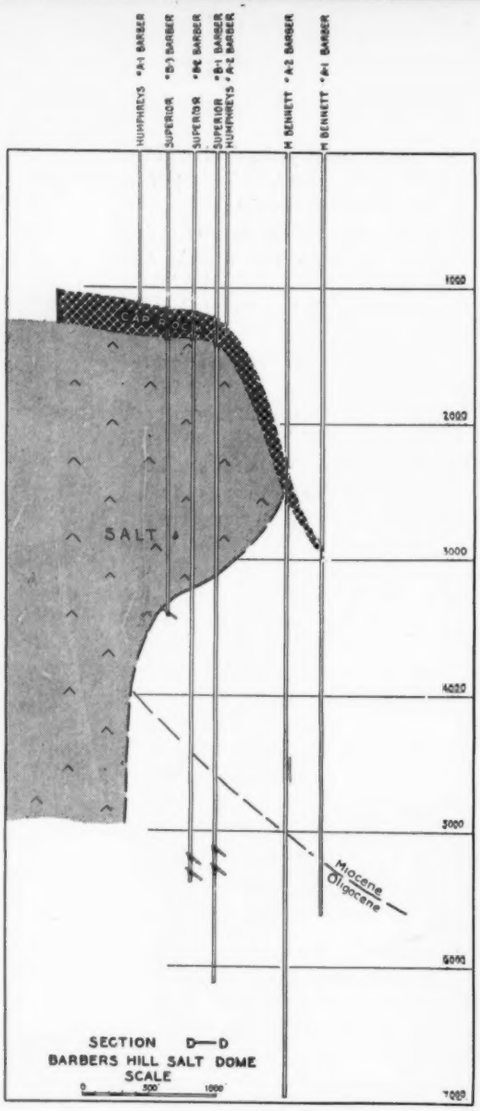
No other formation has been penetrated lower than the *Vicksburg* of the Lower Oligocene Age at Barbers Hill. There have been several wells which cored material which contained *Jackson foraminifera*, however, in each case such cores were obtained from the *Gouge* zone and this zone does not represent any true formation. The *Gouge* zone is one that lies underneath the salt overhang and also occurs alongside the flank of the salt and this zone consists predominantly of products of secondary mineralization varying from well cemented rock to a loosely consolidated mass. This zone can be well termed as the lubricating medium during the time that the dome and the formations were uplifted and the latter breaking and shearing against the flanks of the dome.

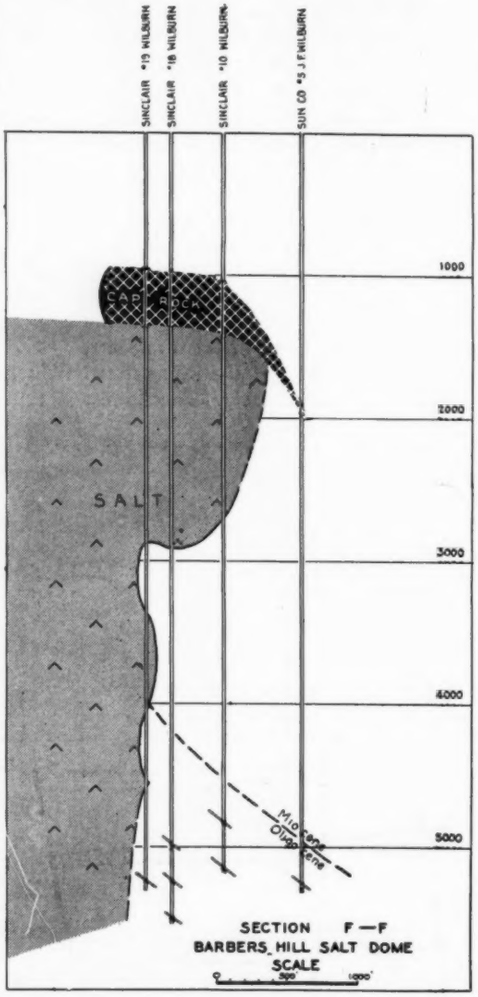
Barbers Hill has one of the most prominent surface mounds of any piercement type dome in the coast. This mound was

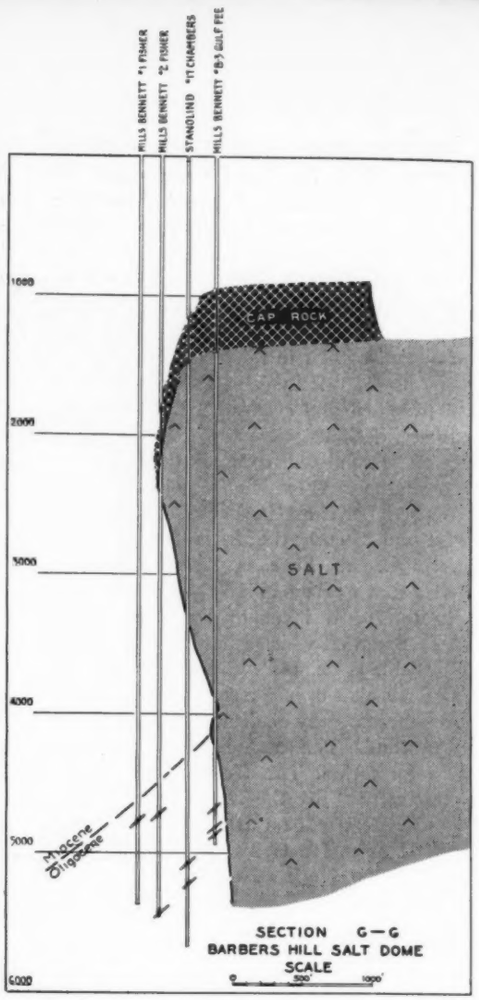
Figure VII: Segment of the Barbers Hill dome which is cut out of the east flank looking west. This figure illustrates the faulting that exists on that flank.

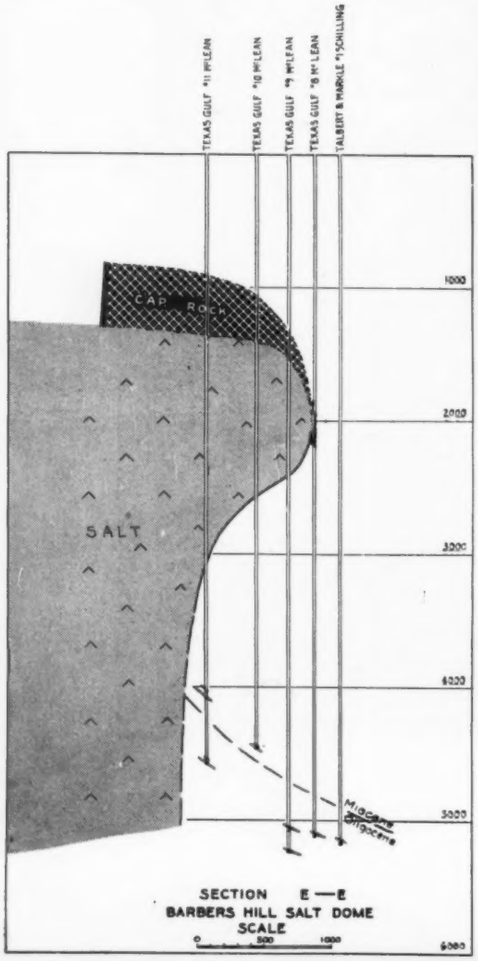


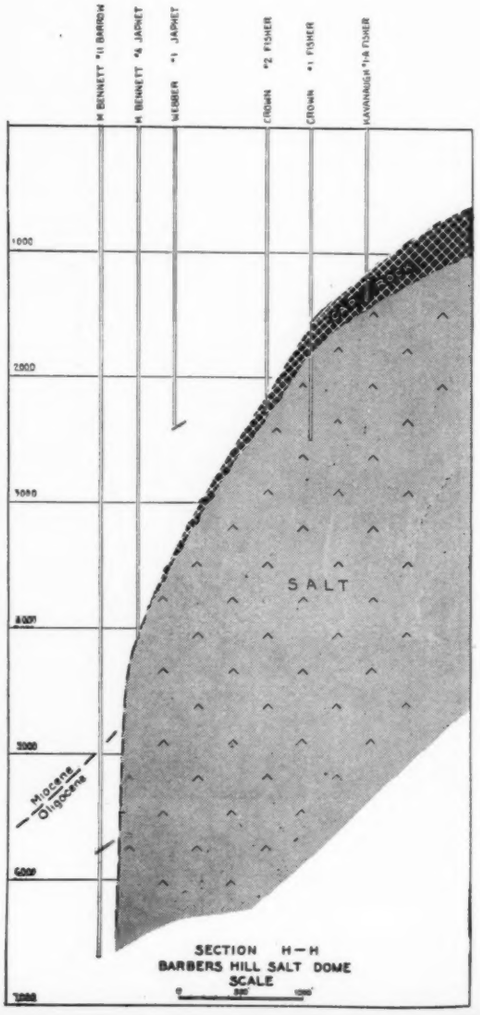
caused by the continuance of uplift in late Beaumont time which carried the caprock to within 350 ft. of the surface. The upthrust of the dome reached major proportions during the deposition of the Lower Pliocene formation and continued well into the Beaumont time of late Pleistocene Age. The surface mound at Barbers Hill was probably formed during the latter part of Beaumont time. The subsurface formations surrounding and overlying the dome have been subjected to intense strain and stress during uplift and major and minor faulting











Cross sections D-D through H-H from Figure V on page 45.

is evident in these formations on the flanks of the dome. The faulting that has been definitely ascertained is classified as radial faults.

Figure III shows the relationship of the Barbers Hill Salt Dome to the Esperson Salt Dome and also the general outline of the formations in that particular area. This figure is part of a geologic cross-section through Southeast Texas which

shows the generalized structure and stratigraphy and which was compiled from well logs, surface geology and published data by Thompson[3]. This figure gives a general idea as to the effect of the domes on the formations in any area. The Esperson dome in this figure is considered to be a deep piercement type dome, whereas the Barbers Hill dome is considered to be a shallow piercement type dome. The formations above the Esperson dome are not broken, however, the curvatures of the formations indicate that they were effected by the upthrust of the dome, and in comparison, the Barbers Hill dome has pierced all of the formation into the Pleistocene.

The caprock at Barbers Hill is divided into what might be termed a series of caps. At the base of the series, or directly above the salt, the caprock is uniformly massive anhydrite. Above this anhydrite there is a layer of gypsum and above the gypsum there is a layer of limestone. This caprock varies in thickness from 850 ft. in the central portion of the dome to a few feet at the outer edges. The caprock as a whole is not uniform and varies in characteristics due to the presence of cavities and concretions. In some of the pore spaces a small amount of sulphur calcite is deposited in crystal form and some of the crystals have rounded edges indicating solution by circulating ground waters[4].

The outline of the dome can be well ascertained by reference to Figure No. IV which shows the contours based on top of the caprock. This figure also shows the outer edge of the salt. From the contours of the caprock the dome presents an oval shaped outline. By comparing the caprock contours with the topographic contours shown in Figure I, the oval shaped northwest-southeast outline is somewhat similar. From a study of this map, Figure IV, the anticlinal shape of the caprock is very evident and is characteristic of most of the domes in the Gulf Coast. The uppermost contour that is shown is 400 ft., however, the caprock comes within 350 ft. of the surface and the deepest caprock ever found at Barbers Hill has been at 4,500 ft. which gives approximately 4,100 ft. of rise in the caprock alone. In this figure is shown a cross section line marked *E* and *W* and which is a cross section through the center of the dome in an east and west direction. This cross section will be later referred to as Figure VI and is the most important of the cross sections in this article.

The most important feature of the Barbers Hill Salt Dome is that it is mushroom in shape because of the overhang

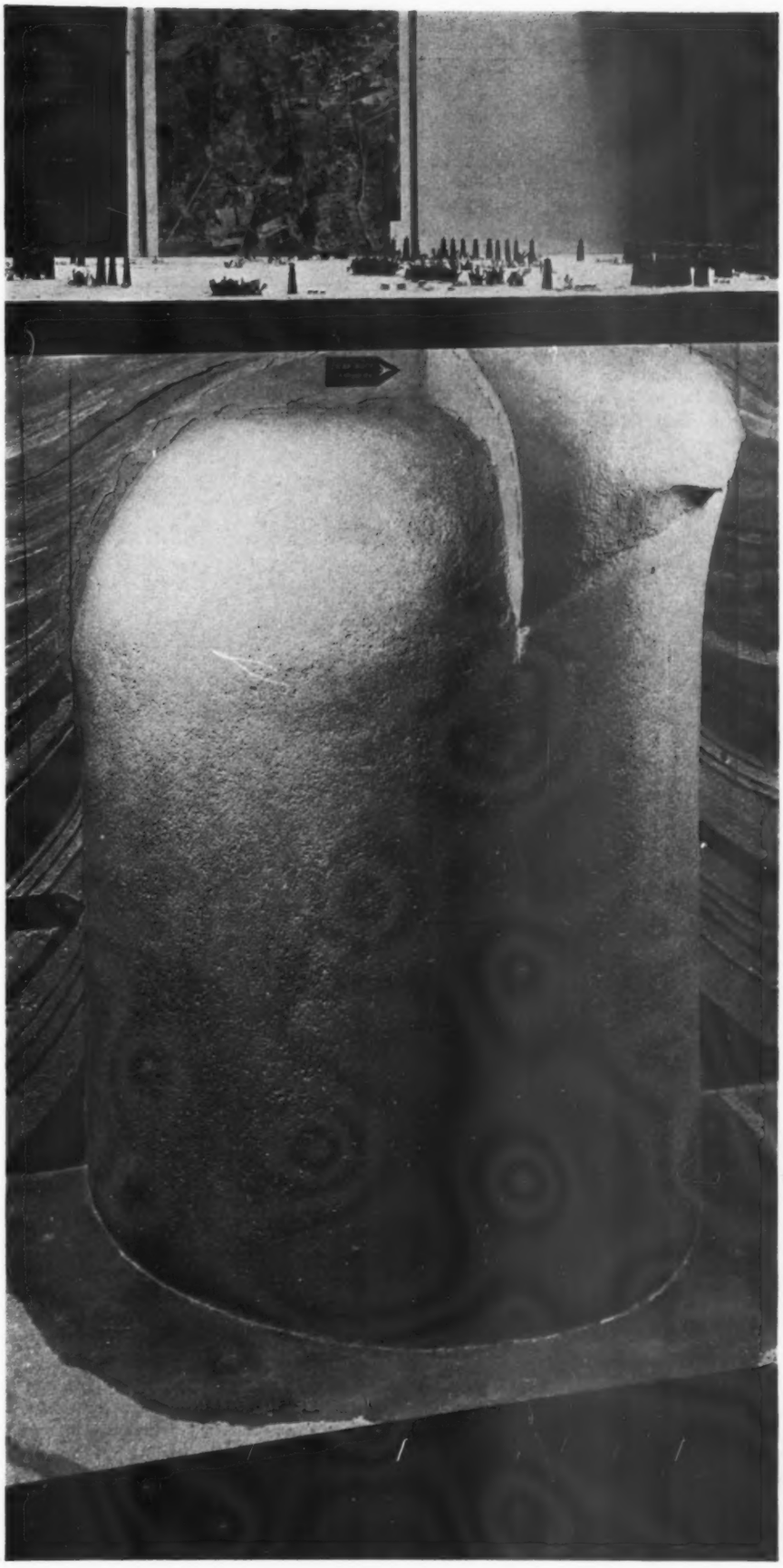


Figure VIII: Scale model of Barbers Hill displayed at the Chicago World's Fair, 1933-1934, as typical of domes on the Gulf Coast.

that is present. Barbers Hill is one of the many domes of the Gulf Coast of Texas and Louisiana which has an overhang. This overhang is economically important because the best wells at Barbers Hill were made from the sedimentary formations underneath the caprock and salt overhangs. The Humphreys Corporation, in the early development of flank production, observed that on the northeast flank the dips of the beds ranging from 3,000 to 4,000 ft. were gentler than those at depths between 2,000 and 2,300 ft. and as the normal dip is steepest nearest the dome, this decrease in dip showed that any well drilled in that area was nearer the dome at the higher level and farther from the flank of the dome at the lower level, and indicated that an overhang of caprock was present[5]. This particular situation exists also at the High Island Dome, Galveston County, Texas, and can be detected in the difference of the dips of Lower Pliocene and Upper Miocene. The difference of dip of the beds at Barbers Hill were so pronounced that the geological department of the Humphreys Corporation purposely drilled their Kirby No. B-5 150 ft. closer to the dome than any other previous well and this well penetrated and proved the presence of the caprock overhang. The salt overhang was not proven until January, 1930, when the same corporation drilled through 878 ft. of salt below the caprock and reached sedimentary beds beneath the salt and was completed as a flowing well in the 5,100 ft. sand. The caprock overhang projects farther outward than the salt overhang. The outer limits of the salt and caprock overhang is shown in Figure V. The overhang is divided into two areas: a shallow overhang area, and a deep overhang area. The shallow section comprises the eastern flank and the deep area on the western flank. Beneath the overhang the Miocene beds are first encountered.

From a study of the cross section, Figure VI, it is observed that the greatest area of the producing horizons is underneath the overhang. A well drilled away from the overhang would miss many of the sands, and would only penetrate the sands at or near the oil-water contact. This is the primary reason that the overhang at Barbers Hill is so economically important: the greatest production is underneath it. In Figure VI, an attempt was made to show the general characteristics of the entire dome. The difference in elevation of the west side to the east side of the dome proper is shown. For instance, the overhang on the west side is approximately at 5,000 ft., whereas the overhang on the east side begins approximately at 2,200 ft. Type wells are shown which illustrate the formations that have been penetrated at the dome. On the west and east flanks, the deepest horizon that has been penetrated by the drill is the Lower Vicksburg. The position of the sands against the dome is clearly illustrated in this cross section and also the number of producing horizons is shown. The large number of producing horizons that exist at Barbers Hill mark this dome from all other domes in the Gulf Coast. In other words, there are more producing horizons in the Barbers Hill dome than on any other dome in the Texas-Louisiana Gulf Coast. There is production at Barbers Hill beginning in the Pleistocene formation and existing into the Vicksburg and it is very possible that production will also be obtained in the Jackson and Yegua formations if exploration is conducted into these formations. Every formation that has been penetrated at Barbers Hill has produced oil. There are approximately 26 producing horizons at Barbers Hill. In this cross

Table II

Wells Drilled Through Overhang Salt—Barbers Hill Dome—Chambers County, Texas

	Operator	Lease		Salt Top	Salt Bottom	Total Salt	T.D.	Completed	Initial Production	Remarks	Flank
1	Humphreys Corp.*	Ilfreys	#9	1531	2409	878	5087	2-26-30	1062		East
2	" " *	McLean	#1	2066	2293	227	5360	3-22-30	1150	Drilled to 6078'—Plugged back to 5360'	"
3	" "	Morgan	#1	2346	2542	196	6404	6-26-30	319	Later deepened to 6469 and abandoned	N.E.
4	" " *	Kirby	C-2	2196	2245	49	5224	6-29-30	20	Small pumper	East
5	Mills Bennett Prod. Co.	Gulf-Fisher	#2	2177	2433	256	4710	7-12-30	1852	Later deepened and completed at 5242'	South
6	Sun Oil Co.	Chambers	#6	2223	2573	350	4124	8-22-30	1000	Later deepened and completed at 4622'	"
7	" " "	Wilburn Fee	#9	2091	2101	10	5167	9-19-30	126		S.E.
8	Mills Bennett Prod. Co.	E. W. Barber	#3	1557	3198	1641	5147	10- 1-30	1450		North
9	Humphreys Corp.*	T. S. Fitzgerald	#1	2115	2664	549	5367	10-19-30	1500		N.E.
10	Yount Lee Oil Co.*	Chambers	#16	2338	2486	148	4733	11-23-30	1320	Later deepened and completed at 5293'	South
11	Humphreys Corp. *	Kirby	B-8	1631	2551	920	5295	11-29-30	1920		East
12	" " *	Barber	A-6	3581	4360	779	5485	12 16-30	982		N.W.
13	Sun Oil Co.	Wilburn Fee	#12	2045	2325	280	5127	12-18-30	580		S.E.
14	Humphreys Corp.*	E. W. Barber	B-1	2085	2721	636	6793	12-26-30	None	Stuck drill pipe—Abandoned	N.E.
15	Sun Oil Co.	Chambers	#7	1836	3092	1256	4583	1-10-31	2013		South
16	Mills Bennett Prod. Co.	Gulf-Fisher	#3	1467	2792	1325	4437	1-22-31	1336	Deepened to 5056—Flowing Well	"
17	Yount Lee Oil Co.‡	Chambers	#17	1453	3341	1888	5054	2- 9-31	180		"
18	Humphreys Corp. *	Kirby	A-10	3120	3346	226	6955	2-20-31	None	Tested Salt Water at 6378'—Abandoned at 6955'	N.W.
19	" " *	L. E. Fitzgerald	#1	1424	3242	1821	5379			Top 2nd Salt 4928—T.D. 5379 Salt—Sidetracked 1700	N.E.
19	" " *	" " "	#1	1424	2963	1539	5199	3-16-31	1977		"
20	Yount Lee Oil Co.‡	Chambers	#18	1758	3383	1625	4465	3-24-31	690		South
21	Mills Bennett Prod. Co.	E. W. Barber	B-1	1415	3112	1697	5320	3-25-31	225		North
22	Sun Oil Co.	Chambers	#8	1833	3188	1355	4521	4- 6-31	1100		South
23	Humphreys Corp. *	Barber	B-2	1389	3239	1850	5079	4-11-31	1852		N.E.
24	" " *	J. F. Wilburn	#2	1715	2007	292	5234	4-24-31	1115		S.E.
25	Yount Lee Oil Co. ‡	Chambers	#19	1870		3821	5691			5691' T.D. in Salt—Plugged back to 800'—Sidetracked	S.
"	" " " " " ‡	Chambers	"	1765	3693	1928	3794	4-30-31	705		South
26	Sun Oil Co.	Wilburn Fee	#14	1527	2620	1093	3914	4-30-31	None	Stuck drill pipe—Abandoned	S.E.
27	Humphreys Corp. *	Anna Davis	#1	1492	2984	1562	5323	6- 6-31	1901		N.E.
28	" " *	T. S. Fitzgerald	#2	1403	2940	1337	5259	6-23 31	1650		N.E.
29	Mills Bennett Prod. Co.	Gulf-Fisher	#4	1521	2903	1382	3044	6-27-31	1728		South
30	Humphreys Corp.*	Fitzgerald-Meadows	#1	1397	3361	1964	4932	7-29-31	1570		N.E.
31	Texas Co.	J. F. Wilburn	#6	1595	2368	773	4509	8- 6-31	3746		East
32	Sun Oil Co.	Annie Higgins	#1	2170	2234	64	5341	9- 7-31	250		South
33	Gulf Prod. Co.	J. F. Wilburn	#5	1674	2387	713	4494	10- 4-31	1700		East
34	McAlbert Oil Co.	J. F. Wilburn	#4	1490	2420	930	4475	10- 4-31	2000		"
35	Texas Gulf Prod. Co.	Eberspacher	#1	1383	2830	1447	5313	10-10-31	1648		N.E.
36	Sun Oil Co.	J. F. Wilburn	#11	1499	2459	960	2610	10-23-31	200	Flowing by heads—25 Gravity Oil	East
37	Mills Bennett Prod. Co.	J. F. Wilburn	#5	1440	2856	1460	4407	10-24-31	3200		"
38	Sun Oil Co.	C. K. Winfree	#2	4661	4979	318	5359	10-28-31		Pumper—Later deepened and completed at 5637'	West
39	Texas Gulf Prod. Co.	Kirby	B-20	1444	2338	894	4401	11- 3-31	1908		East
40	Sinclair O. & G.	J. F. Wilburn	#8	1430	2721	1291	4494	11- 7-31	1400		"
41	Texas Gulf Prod. Co.	Terbutton	#2	1417	2634	1217	3506	11-15-31	712	Flowing by heads	"
42	Texas Co.	J. F. Wilburn	#7	1517	2376	859	4422	11-21-31	650		"
43	Texas Gulf Prod. Co.	Barber	B-3	1381	3605	2224	4868	12- 1-31	1494		N.E.
44	Texas Co.	Lawrence Fee	#2	1422	2667	1245	4425	12- 2-31	90	Flow by heads—Later deepened to 5313' & Aband.	East
45	Mills Bennett Prod. Co.	Gulf Fee	#1	1365	3506	2141	5134	12-16-31	1320		N.E.
46	Gulf Prod. Co.	J. F. Wilburn	#6	1496	2712	1286	4471	12-17-31	960		East
47	Texas Gulf Prod. Co.	Morgan-Fitzgerald	#1	1376	3795	2419	5214	1- 3-32	2189		N.E.
48	Sun Oil Co.	J. F. Wilburn	#12	1496	2518	1022	4472	1- 8-32	1200		East
49	Mills Bennett Prod. Co.	J. F. Wilburn	#6	1386	2939	1553	5034	1-13-32	1922		"
50	" " " "	Gulf-Fisher	#5	1480	3043	1563	4407	1-18-32	2100		South
51	Texas Gulf Prod. Co.	J. M. Fitzgerald	#1	1409	3319	1910	5963	1-19-32	2200		N.E.
52	Sun Oil Co.	Annie Higgins	#2	1424	3549	2125	3648	1-27-32	1600		South
53	Sinclair Oil Co.	J. F. Wilburn	#11	1423	2753	1321	4447	2- 1-32	400		East
54	" " "	" "	#10	1437	2730	1293	4849	2- 8-32	1017		"
55	" " "	" "	#9	1462	2500	1038	4881	2-15-32	812		"
56	Texas Gulf Prod. Co.	Kirby	B-21	1420	2605	1185	5125	2-23-32	1300		"
57	The Texas Co.	J. F. Wilburn	#8	1430	2522	1092	4407	3-17-32	100		"
58	McAlbert Oil Co.	J. F. Wilburn	#5	1405	2942	1537	4325	3-20-32	800		"
59	Gulf Prod. Co.	J. F. Wilburn	#7	1380	2860	1480	4364	3-24-32	500		"
60	Bashara Oil Co.	Terbutton	#2	1414	2575	1161	3634	3-27-32		Small pumper	"
61	Texas Gulf Prod. Co.	M. O. Scott	#1	1377	3471	2094	4174	4-19-32	1368	Orig. T.D. 5629—Plugged back	N.E.
62	" " " "	Kirby	B-9	1374	4171	2797	4245	4-27-32	852		"
63	Mills Bennett	J. B. Means	#3	1435	2551	1116	4445	5-10-32	2500		East
64	Gulf Prod. Co.	J. F. Wilburn	#8	1414	2772	1358	4362	5-16-32	984		"
65	Sinclair Oil Co.	J. F. Wilburn	#12	1386	2693	1307	4312	5-27-32	1500		"
66	McAlbert Co.	Higgins	B-2	1470	2393	923	5197	6- 3-32	359		S.E.
67	Sun Oil Co.	J. F. Wilburn	#14	1462	2629	1167	4385	6-17-32	1300		East
68	Texas Gulf Prod. Co.	Ilfrey	#10	1410	2558	1148	4460	6-17-32	2500		"
69	" " " "	A. E. Barber	A-7	2920	5733	2813	5830	6-17-32	161	Pumping	N.W.
70	" " " "	Kirby	B-10	1396	3128	1732	4376	6-23-32	1500		N.E.
71	Mills Bennett	J. B. Means	#4	1407	2865	1458	4410	7-14-32	1700		East
72	" "	Kirby	#3	1395	2875	1480	4409	7-31-32	2059		"
73	Texas Gulf Prod. Co.	Cornelia Barber	#2	1420	2630	1210	4309	8- 1-32	374		"
74	Mills Bennett	E. W. Barber	A-4	1424	3320	1896	5143	8-21-32	400		North
75	Texas Gulf Prod. Co.	Kirby	B-22	1396	2860	1464	5107	8-27-32	1456		East
76	Rio Bravo Oil Co.	A. M. Fisher	#3	4977	5375	398	6018	8-30-32	Dry	Abandoned 8/30/32	West
77	Texas Gulf Prod. Co.	Kirby	B-23	1388	3101	1713	4210	9-11-32	1248		East
78	Mills Bennett Prod. Co.	Kirby	#4	1370	3031	1661	4204	9-21-32	2246		"
79	Texas Gulf Prod. Co.	Kirby	C-4	1385	3278	1893	3975	9-25-32	1815		"
80	Sun Oil Co.	Higgins	#3	1466	2437	971	3018	9-28-32	300		S.E.
81	Texas Gulf Prod. Co.	Kirby	C-3	1384	3095	1711	5224	9-30-32	608		East

	Operator	Lease		Salt Top	Salt Bottom	Total Salt	T.D.	Completed	Initial Production	Remarks	Flank
82	Texas Gulf Prod. Co.	Illfrey	#11	1382	3077	1695	4034	11-29-32	1211		East
83	" " " "	Kirby	A-11	2932	4784	1852	6130	12-15-32	1409		N.W.
84	" " " "	McLean	#2	1258	2990	1732	4130	12-16-32	874	Orig. T.D. 5315	East
85	Mills Bennett Prod. Co.	Means	#5	1383	3605	2222	4585	12-16-32	Dry Gas	Later made 800 bbls. P.L.O. Per Day	"
86	Texas Gulf Prod. Co.	O. K. Winfree	#2	3971	4821	850	6284	12-17-32	Dry	Top 2nd Salt 6200'—Sidetracked at 2810'	N.W.
87	Mills Bennett Prod. Co.	Kirby	#5	1373	3168	1795	4033	1- 3-33	437		East
88	Texas Gulf Prod. Co.	Tarbutton	#3	1363	3163	1800	4060	1- 8-33	1169	Orig. T.D. 4628	"
89	Sinclair-Prairie	Wilburn	#13	1382	3143	1761	4307	1-14-33	2000		"
90	McAlbert Oil Co.	Wilburn	#6	1400	3921	1821	4328	1-23-33	1250		"
91	Texas Gulf Prod. Co.	Kirby	B-24	1392	3023	1631	4270	2-27-33	1300		"
92	Sun Oil Co.	Wilburn	#15	1432	2612	1180	4520	3- 7-33	351	bbls. fluid. in 6 hrs.—75% Salt Water-Pump	"
				2704	3455	751					
93	Mills Bennett Prod. Co.	Gulf Fee	C-2	4148	4223	75	4604	4-10-33	1750	Salt Twice	South
94	Sinclair-Prairie	Wilburn	#14	1367	2893	1526	4602	4-17-33	812		East
95	Yount Lee Oil Co.‡	Chambers	#21	2456	4745	2289	4904	4-19-33	510	Orig. T.D. 5961 in Salt—Top 2nd Salt 5168	South
96	Humble O. & R.	Kirby	#2	1400	3937	2537	4064	4-24-33	1049		North
97	Texas Co.	Wilburn	#9	1392	3201	1809	3972	4-30-33	18 bbls. Oil-82 Wtr.	—Deepened to 4186 —I.P. 800 bbls. P.L.O.	East
98	Sun Oil Co.	Wilburn	#16	1400	2920	1520	3760	6-24-33	1700		"
99	Texas Gulf Prod. Co	Kirby	B-11	1385	3319	1934	4406	8-30-33	1500		"
100	Mills Bennett	Barber	C-1	1375	3780	2405	4940	9-16-33	1400		North
				2236	3607	1371					
101	Yount Lee‡	Chambers	#22	3894	4021	127	5012	10-19-33	510		South
102	Texas Gulf Prod. Co.	J. M. Fitzgerald	#2	1463	3108	1645	5065	11-29-33	1056		N.E.
103	Sinclair-Prairie	J. F. Wilburn	#16	1390	2787	1397	5002	11-30-33	854		East
104	Humble O. & R.	Kirby	B-4	1424	4182	2758	4287	12-14-33	559		North
105	Texas Gulf Prod. Co.	J. F. Wilburn	#3	1401	2830	1429	4252	1- 1-34	719		S.E.
106	Sun Oil Co.	J. F. Wilburn	#17	1368	2931	1563	4249	2-24-34	682		East
107	Mills Bennett Prod. Co.	E. W. Barber	D-1	1362	3650	2288	4370	3-28-34	726		North
108	Yount Lee Oil Co.‡	Phillips	#7	1417	2694	1277	4477	3-29-34	255	30% S.W.	S.E.
109	Texas Gulf Prod. Co.	Kirby	B-12	1375	3360	1985	4930	4-16-34	818		N.E.
110	Sun Oil Co.	Higgins	#4	1415	3564	2149	3805	4-21-34	745		South
111	" " "	Wilburn Fee	#15	1494	2793	1299	5090	4-25-34	312		S.E.
112	Sinclair-Prairie	Wilburn	#15	1378	2912	1534	4992	5- 3-34	995		East
113	Sun Oil Co.	Wilburn	#18	1415	2700	1285	5130	5- 5-34	944		"
114	Yount Lee‡	Chambers	#23	1449	3762	2313	4322	5- 5-34	600		South
115	Sun Oil Co.	Wilburn	#21	1396	2944	1548	3915	5-22-34	143		East
				1620	4866	3246					
116	Humble O. & R.	Kirby	B-5	4952	5007	55	4940	5-26-34	450		North
117	Sinclair-Prairie	Wilburn	#17-A	1380	3130	1750	4951	6- 3-34	601		East
118	Sun Oil Co.	Wilburn	Fee 16	1421	2716	1295	5056	7-10-34	715		S.E.
119	Yount Lee‡	Phillips	#8	1401	2812	1411	4282	7-12-34	600		"
120	Texas Gulf Prod. Co.	J. F. Wilburn	#4	1353	2993	1640	5058	7-17-34	62	by heads	"
121	Yount Lee‡	Chambers	#24	1456	3760	2304	4026	7-19-34	240	Fluid. 10% S.W.	South
122	Sun Oil Co.	Higgins	#5	1392	3698	2306	4151	7-21-34	702		S.E.
123	" " "	Chambers	#9	1885	3263	1378	3908	7-27-34	187		South
124	Texas Gulf Prod. Co.	A. E. Barber	A-8	3966	3999	33	5549	8- 1-34	520		N.W.
				1402	3938	2536					
125	Mills Bennett Prod. Co.	Gulf Fee	B-3	3990	4246	256	4717	8- 3-34	357		South
126	" " " "	Wilburn	B-9	1390	3297	1907	4228	8- 4-34	567		East
127	Moody Corp.	Barber	A-5	1419	4409	2990	4545	8-19-34	811		North
128	Humble O. & R.	Kirby	B-6	1873	4835	2962	4880	8-19-34	103		"
				1392	3282	1890					
129	Moody Corp.	Barber	A-6	3380	3535	155	4217	8-25-34	435		"
130	Sinclair-Prairie	Wilburn	#18	1379	2916	1537	5041	9-28-34	475		East
131	Yount Lee Oil Co.‡	Chambers	#26	1750	3546	1796	3804	9-30-34	310		South
132	Texas Gulf Prod. Co.	A. A. Eberspacher	#2	1373	3530	2157	5337	10- 1-34	150		N.E.
133	Mills Bennett Prod. Co.	Wilburn	B-10	1369	3505	2136	4861	10-21-34	333		East
134	Yount Lee‡	Phillips	#9	1403	3901	1498	3719	10-31-34	220		S.E.
135	Texas Gulf Prod. Co.	Wilburn	#5	1400	2940	1540	4202	11- 1-34	358		"
136	McAlbert Oil Co.	Wilburn	#7	1380	3542	2162	4793	11-11-34	421		East
137	Texas Gulf Prod. Co.	E. W. Barber	B-4	1400	3291	1891	4241	11-27-34	774		North
138	Yount Lee‡	Chambers	#25	1454	3535	2081	4750	12- 6-34	170		South
139	Sun Oil Co.	Higgins	A-6	1403	2749	1346	4338	12-14-34	1041		S.E.
140	" " "	Wilburn	#22	1397	2930	1533	4074	1- 3-35	423		"
141	Humble O. & R.	Kirby	B-7	1853	4680	2827	5211	1-12-35	540		North
142	Sun Oil Co.	Chambers	#10	1954	3140	1186	3910	1-14-35	479		South
143	Texas Gulf Prod. Co.	O. K. Winfree	#3	3960	4089	129	5703	2- 3-35	515		West
144	Texas Co.	Wilburn	#10	1378	3537	2159	4838	2-15-35	430		East
145	Yount Lee‡	Chambers	#27	1685	3865	2180	4513	2-18-35	340		South
146	Texas Gulf Prod. Co.	T. S. Fitzgerald	#3	1397	3690	2293	4116	3- 2-35	364		N.E.
147	Superior	Barber	C-1	1384	3481	2097	5200	3- 7-35	524		North
148	Sun Oil Co.	Wilburn	Fee 17	1490	2890	1400	3195	3-30-35	84		S.E.
149	Humble O. & R.	Kirby	B-8	1438	3662	2224	5040	4-10-35	453		North
150	Texas Gulf Prod. Co.	Morgan-Fitzgerald	#2	1375	3655	2280	4563	4-20-35	551		N.E.
151	McAlbert Oil Co.	Higgins	B-2	1447	2682	1235	4825	5-13-35	468		S.E.
152	Stanolind	Chambers	#28	1779	3624	1845	4557	5-18-35	435		South
153	Texas Gulf Prod. Co.	J. M. Fitzgerald	#3	1407	2926	1519	4619	5-29-35	467		N.E.
154	" " " "	Kirby	A-12	2908	4589	2381	5334	6- 2-35	478		N.W.
155	" " " "	J. F. Wilburn	#6	1399	2882	1482	4795	6-12-35	347		S.E.
156	Mills Bennett	E. W. Barber	C-2	1393	3780	2387	5959	6-26-35	342		North
157	Texas Gulf Prod. Co.	Fitz.-Meadows	#2	1395	3598	2203	4071	7- 1-35	338		N.E.
158	" " " "	Kirby	B-25	1393	3036	1643	5121	8-18-35	516		N.E.
159	Stanolind	Chambers	#30	1708	3594	1886	4508	8-19-35	320		South
160	Sun Oil Co.	Chambers	#11	1873	3187	1314	5464	8-24-35	400		South
161	" " "	Higgins	#7	1400	2785	1385	5090	9- 3-35	142		S.E.
162	Superior O. & G. Co.	Barber	B-2	1396	3207	1811	5379	3-16-36	152		North
163	Stanolind	Chambers	#31	1857	3402	1545	5686	8-22-36	134		South
164	Sun Oil Co.	Wilburn Fee	#18	1446	2498	1052	5619	3-12-36	100	With 30% S.W	S.E.
165	Stanolind	Z. T. Wilburn	#20	1745	2388	643	6002	3-22-36	137		S.E.
166	Texas Gulf Prod. Co.	J. F. Wilburn	#7	1418	2588	1170	5350	3-27-36	69		S.E.
167	Sinclair-Prairie	J. F. Wilburn	#19	1378 3349 4533	2867 4067 4561	1489 718 28	5303	4-23-36	457		East
168	Superior	Barber	B-3	1388	3336	1948	3407	5- 8-37	506		North
169	Texas Gulf Prod. Co.	Kirby	B-26	1371	3250	1879	5324	8-25-37	531		N.E.
170	" " " "	Kirby	A-13	2123	4832	2709	5524	11- 7-37	533		N.W.

* Now being operated by Texas Gulf Producing Co.
‡ Now being operated by Stanolind Oil & Gas Co.

section the *Gouge zone* is also shown as being part of the immediate flanks of the dome. The approximate positions of the sands in the Yegua and Jackson formation have been shown in this cross section, however, whether they exist or not as shown is problematical. The only reason why they were included as such in the cross section is to show that there are sands in these two formations based upon data elsewhere. It is to be noticed that the *Gouge zone* does not extend above the caprock but is prolonged along the flanks of the dome. The positions of the caprock series is shown in this cross section. The thickness of the formations are also shown. A comprehensive study of this cross section would enable the reader to obtain a very good idea as to the general outline as well as productive horizons and positions of the horizons at the Barbers Hill Dome.

Figure VII illustrates the condition that exists on the east flank. This figure represents a segment of the dome which is cut out on the east flank looking west. This particular drawing illustrates the faults existing on this flank and the position of the producing sands in respect to the faults.

Accurate paleontological data must be kept during the drilling of the wells on this particular flank because confusion might be evident in determining the producing sands in wells drilled in different segments caused by the faults. In other words, if a well is drilled in segment No. 1 and the "E" sand is penetrated and production obtained therefrom, the depth of the "E" sand would be very close to the bottom of the "D" sand which is present in segment No. 2. In segment No. 3, the bottom of the "C" sand would correlate with the top of the "D" sand and in segment No. 4, the "E" sand would correlate with the "C" sand in segment No. 3. If wells were drilled and produced from the "E" sand in segment No. 1, "D" sand in segment No. 2, "C" sand in segment No. 3, "E" sand in segment No. 4 and "D" sand in segment No. 5, one could easily presume that these sands were in one body which would be very erroneous. The throw of the faults placed four sands at more or less similar depths, however, accurate correlation showed that these sands are different. Accurate paleontological data, as well as accurate correlation of individual horizons, are extremely important because one sand might be non-productive and the presence of a different sand at the approximate same depth, which was placed accordingly by faulting, would be productive, however, the knowledge that the first sand is non-productive would probably influence the operator to refrain from setting in a sand at a similar depth because of the possibility of obtaining water instead of oil. There is no question that faulting controls production at Barbers Hill and that the only possibility of eliminating mistakes in correlation of sands is by either paleontological or petrographical study of the formations and sand bodies.

Figure VIII shows a picture of the model of the Barbers Hill salt dome which was placed on exhibition at the Century of Progress in Chicago in 1933.

By referring to Figure V, the position of cross section A-A is determined. In this cross section A-A is shown the names of some of the important wells which penetrated the overhang and the position of the overhang through this part of the dome. It is to be noted that on the South side of this cross section several wells have penetrated into the Lower Oligocene (Vicksburg) formation. The approximate positions of some of the producing sands are also shown in this cross section. It is especially important to note the wavy condition of the overhang

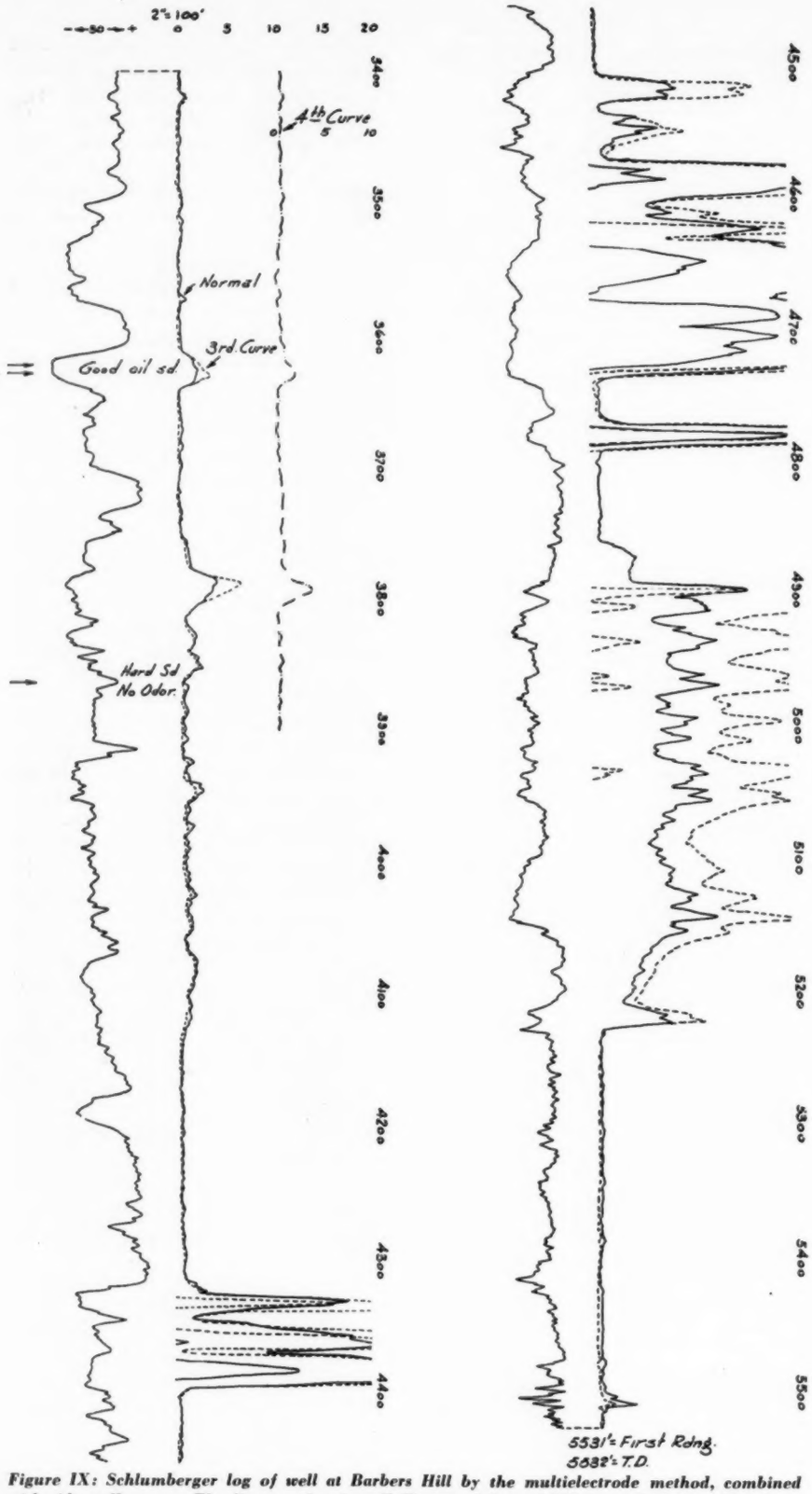


Figure IX: Schlumberger log of well at Barbers Hill by the multielectrode method, combined with side wall cores. The lime section is well illustrated from 4,320 ft. to 5,225 ft. The lower producing oil sand, 5,500 ft. to bottom, is outlined by both the third and fourth curves. Another sand, showing resistivity at 3,610 ft. to 3,640 ft. on both the third and fourth curves, was checked by side wall samples which showed it to be an oil sand, and which heretofore had been unknown. The arrows indicate depths at which side wall cores were obtained. There is a possibility of the sand at 3,800 ft. carrying oil, however, this was not checked by side wall cores, but the third and fourth curves show good resistivity.

in the Stanolind Oil & Gas Company's No. 21 Chambers, in which the well has penetrated underneath the overhang into formations and back into salt and thence out of it again into sedimentary formations.

By referring to Figure V, the position of cross section B-B is ascertained and in this cross section, the lopsided position of the overhang is shown; that is, on the east side, the overhang is much higher than on the west side.

In cross section C-C, which is located on the northwest flank of the dome, is shown the approximate position of the overhang in that sector. Most of the producing wells in that area are from the Oligocene.

In cross section D-D, which is located on the north flank of the dome, is shown the overlapping condition of the caprock which protrudes away from the salt. This condition forms a dual overhang, one of caprock and one of salt. It will be observed that by a comparison of cross section C-C and cross section D-D, the overhang depth begins to decrease as a clockwise direction is assumed.

Cross section E-E, which is on the east-northeast flank of the dome, shows that the overlapping caprock begins to fall back towards the salt. In this particular area both Miocene and Oligocene production is obtained.

Cross section F-F, which is located on the east side of the dome, shows the protrusion of the caprock away from the salt forming a dual overhang of caprock and salt and also shows the irregularity of the flank of the salt of the dome. In the Sinclair No. 19 Wilburn well, the overhang proper was penetrated from 900 ft. to 2,800 ft., thence going into sedimentary formations, and the salt again encountered at approximately 3,300 ft., going out of it again at 4,100 ft. back into sedimentary formations and again hitting a small finger of salt at approximately 4,600 ft., going out of it again after a 50-ft. penetration into sedimentary formations, and thence making a well into the Oligocene.

In cross-section G-G, which is located on the southeast flank of the dome, the relationship of the caprock and salt to form an overhang is shown, and the irregularity of the flanks of the salt at lower depths is also illustrated. Where penetration of small bodies of salt, as shown in the Mills Bennett No. B-3 Gulf Fee well, is indicated, such small bodies are called "fingers" and are known to protrude away from the main body of salt.

Cross section H-H, which is located on the south flank of the dome, shows the relationship of the caprock and salt where the caprock gently pinches out at the edge of the salt, and from wells so far drilled in this area, an overhang has not been estab-

lished, nevertheless, it is believed that the possibility of an overhang at deeper depths is probable.

Table No. II shows the number of wells which were drilled through the overhanging salt at the Barbers Hill dome. This table does not include those wells which were drilled only through the caprock overhang. There have been approximately 170 wells drilled only through the salt overhang. In this table, the flanks on which these wells are located are given, also the initial production of each well.

PRODUCTION METHODS

Production methods at Barbers Hill are similar to ordinary Gulf Coast drilling, however, in the drilling of several wells, unusual domal conditions were found which necessitated special drilling and engineering technique. Rotary rigs are and have been used in the drilling of all of the wells at Barbers Hill. Due to the flat and barren terrain on the flanks of the dome, and because of the close proximity of the locations, operations from one move to another are completed in 24 hours and drilling commenced on the second day. In many instances, one boiler set-up has drilled 12 wells and one set of mud pits have served as many as five wells. Overhang wells encounter hard formation in the caprock which slows the drilling time, and special care must be given to the mud when drilling in salt. Drilling in the sedimentary formations below the overhang is rather fast, however, the average drilling time for a 6,000 ft. hole at Barbers Hill is 60 days, which includes completion. Wells made in the 4,100 and 4,800 ft. sands are completed in 45 to 50 days and wells completed in the 5,100 ft. sand require approximately 55 days.

In drilling through the caprock some wells have encountered cavities which have caused the circulation of the mud to become lost. Special drilling technique and mud control have overcome these conditions either by setting cement in the cavities to fill them up or by using sawdust, cotton seed hulls, etc., to serve the same purpose as cement. Three or four days are lost in overcoming this difficulty, after which casing is set below the cavities which prevents further loss of circulation. Conductor pipe from 18 to 22 in. O.D. is set from the surface to depths ranging from 150 ft. to 300 ft. which is all the pipe needed until it is determined whether or not cavities are found. If no cavities are encountered, the 10¾ in. O.D. surface casing is set from 1,000 to 1,200 ft. Operations below the surface casing are made with a 9⅞ in. bit, and the mud weight is maintained from 9.4 lbs. per gallon to 9.6 lbs. per gallon. The colloidal strength of the mud is kept relatively high and the A.P.I. viscosity measurements are from 38 to 40 sec. Coring for the sands is done with either the conventional barrel or the wire line core method, however, recent wells are cored by the latter barrel. Previous to 1937, all cores were taken with the conventional barrel which slowed up drilling time considerably. The wire line method prevents numerous trips out and in the hole with the drill pipe. After the sand is cored, seven inch O.D. pipe is set as the oil string either through the sand for a perforation production test, or immediately above the sand, which necessitates an open screen setting. Both methods are successful. Screen sizes range from .006 gauge for the upper fine sands to .010 for the lower Frio sands. Wells are washed in with clear water and brought in under small chokes. What gas there is available is used in present operations to fire the boilers, but individual operators at times have found that both gas and oil were needed to finish drilling some wells. The

Courtesy Edgar Tobin Aerial Surveys

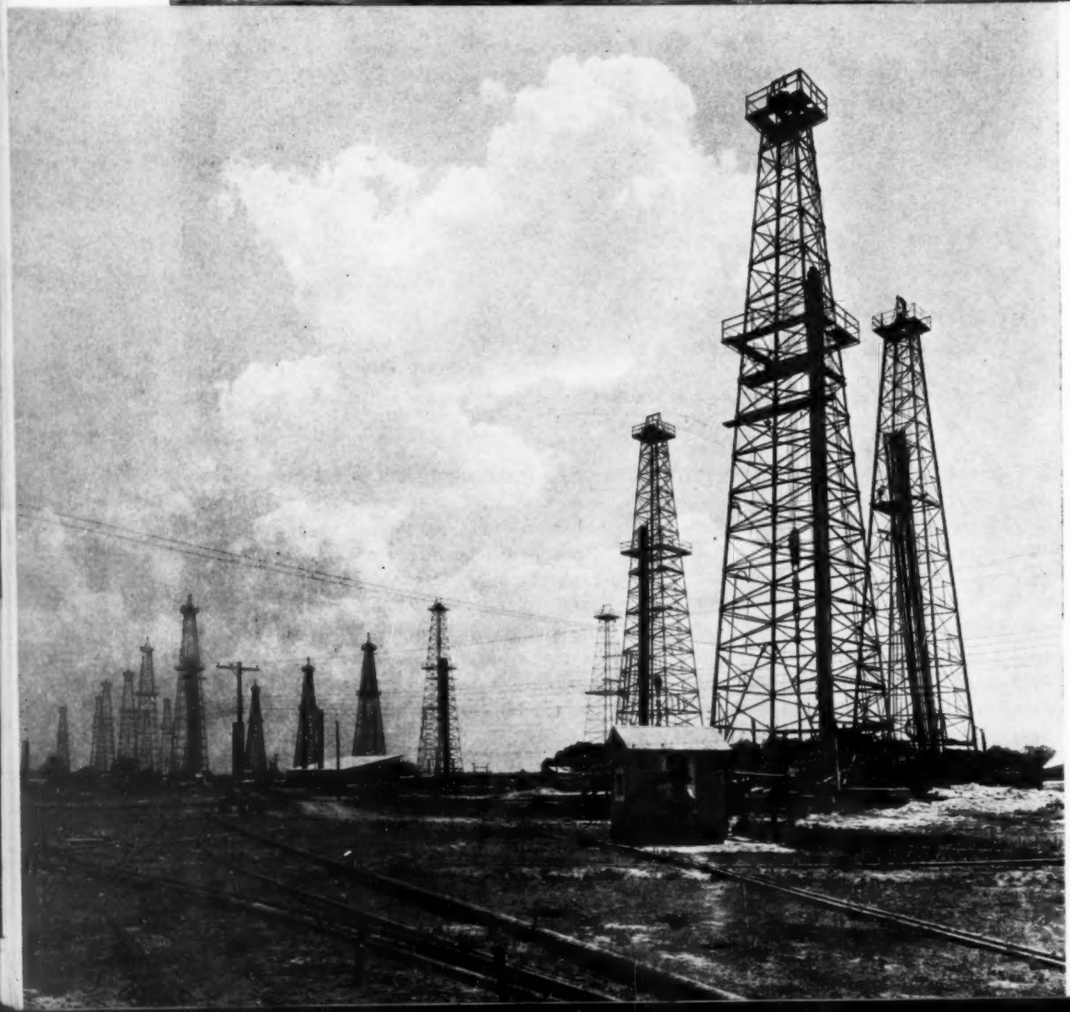
Figure X: Aerial photo-mosaic of Barbers Hill area, Chambers County, Texas.

gas-oil ratio per well is very low and the quantity of gas for drilling operations is rather small.

RESERVES

Based on the volumetric method of computing oil reserves, the ultimate recoverable oil from the proven productive area of the Barbers Hill Field is estimated to be a total of 125,000,000 bbl. The factors involved are proven acreage, sand thicknesses, permeability, porosity, saturation, connate water percentages, shrinkage percentages, and the portion of oil which will be recovered. The proven productive area of the field is 650 acres. This acreage includes the area in which development has proven leases in both horizontal and peripheral directions. In fields of the Barbers Hill type, i.e., where the structure is a piercement type salt dome, the formations are upthrusted and pierced by the intrusion of salt which forced the horizons to dip away from the salt plug at various angles. The producing horizons at Barbers Hill lay vertically underneath each other which formulates a continuous oil section (refer to Figure VI.). The vertical oil section underneath the overhang, if added together would total over 500 ft. in thickness, but the horizons dip in many angles away from the dome which not only diminishes the thickness of the oil section, but also decreases the thicknesses of the producing sands and volume of oil.

There are 26 producing sands recorded at Barbers Hill. The thickness of the bodies varies from five to 60 ft. The sands have been well cored and the cores tested for the physical characteristics such as porosity, permeability, grain sizes, and saturation. The sands are loose and unconsolidated and the effective porosity varies from 20 to 30 percent. The hydrostatic drive of the salt water below the oil, which is continually forcing the oil up the dips toward the highest portion of the sand bodies tends to increase the final recovery of the oil. This final recovery is estimated to be 55 percent. The recovery from an acre foot of oil sand is calculated at 1,200 bbl. The ultimate recovery per acre is estimated at 192,300 bbl. Schlumberger electrical logs have proven the presence of heretofore unknown sands which have been tested and found to be very prolific. These new sands have been a major factor in increasing the ultimate recoverable oil at Barbers Hill. Schlumberger electrical logging has been used in Barbers Hill since it was first introduced in the Gulf Coast (first survey at Barbers Hill in July, 1933). These surveys have aided operators in locating many sands and some companies use it exclusively without mechanical coring. Introduction of Schlumberger multi-electrode recording and side wall sampling has still further reduced the need for coring. Figure IX is an example



Left—East flank of the Barbers Hill dome looking northeast. Above—Texas Gulf Producing Company's camp; the concern is the largest operator at Barbers Hill.

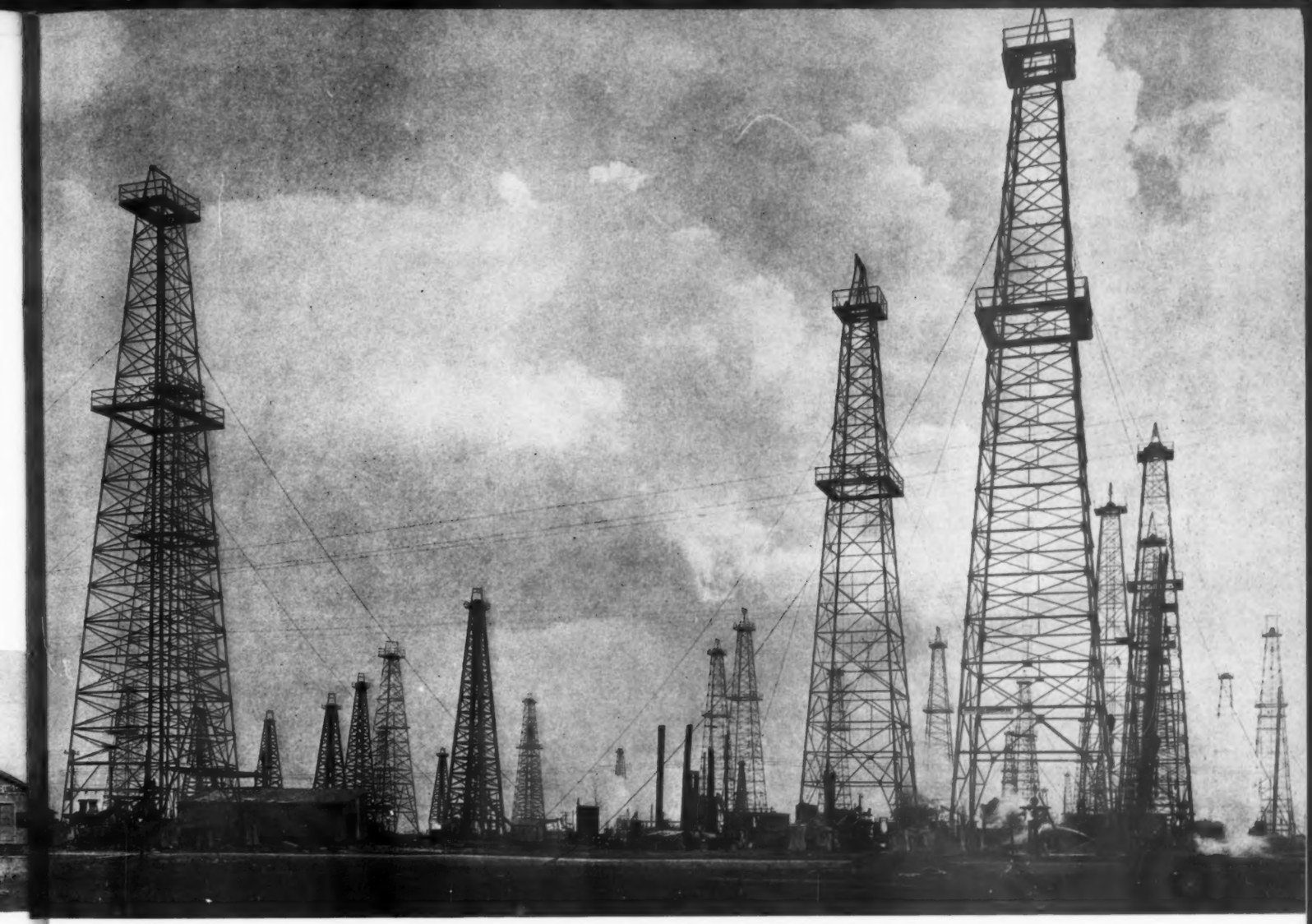
of a well recently surveyed in Barbers Hill by the multi-electrode method combined with side wall sampling. By referring to this Figure one can obtain a good idea as to the methods employed at Barbers Hill in establishing new oil horizons which were drilled through in the early drilling.

Through October, 1938, 64,015,498 bbl. of oil have been produced at Barbers Hill, leaving an estimated future recoverable reserve of 60,984,502 bbl.

Because of the producing horizons existing in the caprock, Pliocene, Miocene, Middle Oligocene, and Lower Oligocene formations, the oil produced at Barbers Hill ranges in Baume gravity from 17 deg. to 35 deg. As a general rule, the higher gravity grades are found in the lower sands. The present average price per barrel of oil is $1.01.

PRORATION

Production at Barbers Hill is controlled by the Texas Railroad Commission. Each



Northeast flank of Barbers Hill dome looking southeast.

well is prorated according to the factors set by the Commission, and the production per well under proration has varied from 60 bbl. to 175 bbl. per day. The figure for each well is set every month. The development through October, 1938, totaled 599 tests, 427 made oil, and 172 were considered as dry. At the present time, there are 169 wells producing in the field: 47 of these are flowing wells and 122 are pumping wells. The average gas-oil ratio per well is 184, and the total average daily gas production per well is 16,900 cu. ft. The average well head pressure on flowing wells is 500 lbs. per sq. in. The average well potential on a 1/8-in. choke is 175 bbl. per day. New wells affect the proration schedule as these wells increase the field production and necessitate a decrease per well allowable. At this writing, the average per well allowable, including pumping and flowing wells, is 64 bbl. per day for the field, or 325,500 bbl. per 30-day month. At a rate of proration based on 325,500 bbl. per month, the field would produce 189 months or approximately 16 years.

ACKNOWLEDGEMENTS

The Barbers Hill Salt Dome was first described in a paper by Bevier[6] who fully reported on the dome and its activities up to the year 1925. Later in 1930, Murphy and Judson[7] reported on the deep sand development at Barbers Hill. Still later in 1932, Judson, Murphy and Stamey[7] described in detail the overhanging caprock and salt at Barbers Hill. The author wishes to express his appreciation to Sidney A. Judson, Chief Geologist for the Texas Gulf Producing Company, for his many suggestions and criticisms, for much data which were furnished the author, and for his permission to use several of the figures which he had so ably constructed. Appreciation and thanks are also extended to the Texas Gulf Producing Company for the valuable assistance accorded the author in making certain data available and for the kind consideration given in the publication of this article.

[2]Donald C. Barton, "Reading the Aerial Photo-Mosaic of the Barbers Hill Area, Chambers County, Texas." Gulf Coast Oil Fields, A.A.P.G. Publication, p. XVII, 1936.

[3]Wallace C. Thompson, "Geologic Sections in Texas and Adjoining States," Bull. A.A.P.G. Vol. 21, No. 8, August, 1937, plate C.

[4, 6]George Bevier, "Barbers Hill Salt Dome," Bull. A.A.P.G. Vol. 9, No. 6 (September, 1925).

[5, 7]P. C. Murphy and Sidney A. Judson, "Deep Sand Development at Barbers Hill, Chambers County, Texas," Bull. A.A.P.G. Vol. 14, No. 6 (June, 1930).

[8]Sidney A. Judson, P. C. Murphy and R. A. Stamey "Overhanging Caprock and Salt at Barbers Hill, Chambers County, Texas," Bull. A.A.P.G. Vol. 16, No. 5 (May, 1932).

Texas Gulf's Ilfrey No. 2 on the east flank was first to establish production beneath the overhang with 1,062 bbl. daily.

HYDROGENATION AS A STEP

STEADY EXPANSION of Italian oil refining facilities under government stimulation indicates that the petroleum industry in that country will continue to import crude in greater quantities, and having met the commercial and military requirements will export finished products—the Aquila and Fiume refineries already are exporting lubricating oils and other products to the Italian colonial empire and neighboring countries.

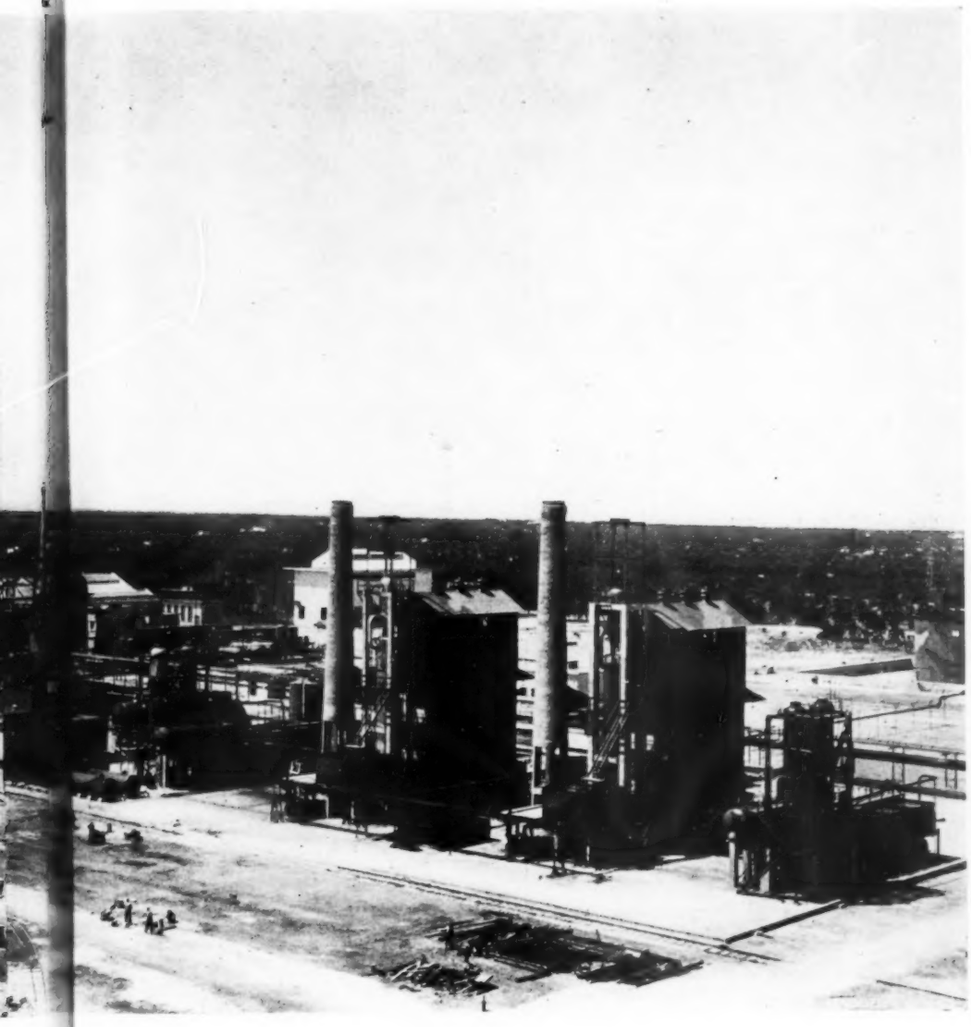
His Excellency Benni, Italian Minister of Communications and chairman of A.N.I.C. (Azienda Nazionale Idrogenazione Combustibili) inaugurated the first of the two hydrogenation plants erected at Livorno November 12th, 1938. The second plant is at Bari, opposite Albania. A.N.I.C. is a 500,000,000 lire concern allied with the Montecatini chemical company as well as the government controlled Azienda Generale Italiana Petroli and its subsidiary Azienda Italiana Petroli Albania. The latter is administered by the government's communications department, which obtained the Albania oil concession.

The two hydrogenation plants, which may be followed by a third, treat for the most part the low-grade petroleum of Albania. Although this sulphurous crude is of poor quality, it is at present the only important oil reserve (12,000,000 tons) under Italian control. In order to make the best of this charging stock the Italian government decided to adopt hydrogenation, which will permit the extensive replacement of oil supplies imported from Iraq by Albanian petroleum and the oil obtainable from Italian asphalts, shales, and lignite tars.

Although only just officially opened, the Livorno plant was first put on stream in September. The refinery is complete with distillation units, cracking plant, and solvent treating. The hydrogenation process incorporated is a high pressure high temperature development of the Bergius patents, made by M. G. Levi, C. Padovani, and N. Parravano, by which it is possible to increase the yield of gasoline from 40 percent to more than 80 percent—simple distillation gives but 12 percent gasoline.

Because the hydrogenation process is at present applied to petroleum as in the United States, rather than to coal as in Germany and Britain, the operating costs are different and A.N.I.C. hopes to avoid or reduce the state subsidy. This is especially the case as the process will be employed to produce some 60,000 tons of high quality lubricants annually, as well as 100 octane gasoline—import of which products has previously upset the commercial balance of Italy.

Toward Italian Oil Autarchy



Italy's new hydrogenation plant at Bari, operated by Azienda Nazionale Idrogenazione Combustibili (A.N.I.C.), is used for treating Albanian crude.

The two plants together will produce 240,000 tons of automobile and aviation gasoline, corresponding to half the national consumption, but may be increased to 400,000 tons. Most of the materials required were produced by the metallurgical industry in Italy; although, England and Germany furnished the high pressure vessels capable of withstanding 300 deg. C. and 300 kg. per sq. cm., constructed with special corrosion resistant alloys of chromium, nickel, and molybdenum. The area of the Livorno installation is 500,000 sq. m., of which 60,000 sq. m. is covered by the plant itself. There are 150,000 m. of pipeline, 50,000 m. of electric wire and the aggregate weight of the plant is 26,000 tons.

The storage facilities at Livorno amount to 120,000 cu. m. Most of the tanks are equipped with a nitrogen circulation system to prevent the accumulation of explosive mixtures. All tanks are so surrounded with concrete walls to limit the extent of fire in case of rupture. The 20,000 hp. electric power plant is supplied by the energy produced through the boracic *soffioni* of Larderello.

The A.N.I.C. has at its disposal at Novara, near Turin, a large laboratory for the manufacture of catalysts and special apparatus and where fuel research is conducted and experiments in hydrogenation are carried out.

The new hydrogenation plants in Italy are not only of political interest for defense purposes, but also of economic importance due to the fact that until new methods are developed by the country's technicians for extraction of tars for lignite and oil from shale, the Bari and Livorno plants cannot rely upon domestic sources. Howeve , there will be a reduced loss of international exchange balance by Italy as the plants will permit of increased cheap crude oil imports rather than continued purchases of high quality gasoline and lubricating oils. This also will permit increased consumption of motor fuel and possibly leave a surplus for export.

In fact, after completion in 1937 of the large refineries of A.G.I.P. in Venice (Porto Marghera) and Aquila at Trieste, Italy exported during 1938 appreciable quantities of gasoline and kerosene to Germany and Italian colonies and fuel oil residues to Germany, Switzerland and other continental countries. Moreover, now that consumption of gasoline has been cut to 340,000 tons yearly and production of gasoline by Italian refineries has risen to 500,000 tons per annum, the government has abolished the circulation tax on motor vehicles and increased the quantities of petroleum products which may be marketed by the major companies.

Despite the increased activity in refinery construction in Italy, those plants already in existence are not operating to full capacity as the domestic market in not great enough to cope with their combined output. Several new plants have been put into service during the past year and the A.B.C.D. refinery now belongs to Societa Permolio, Milano. It is doubtful as to whether the projected installation at Tripoli, in Libya, will be put into operation during 1939.

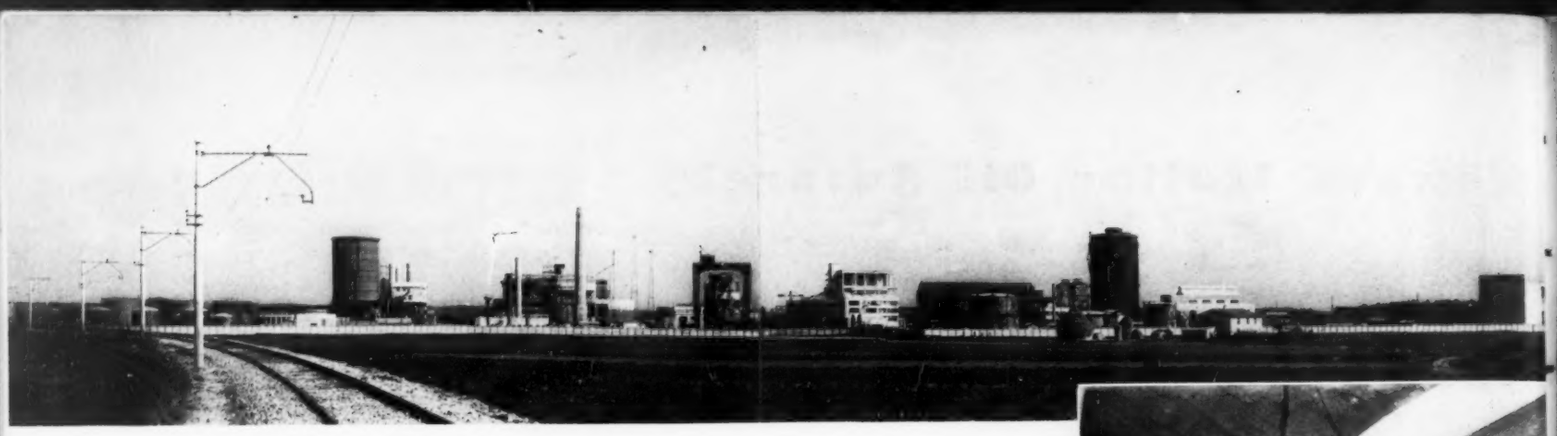
Prorated Oil Market Quotas for 1938 in Italy

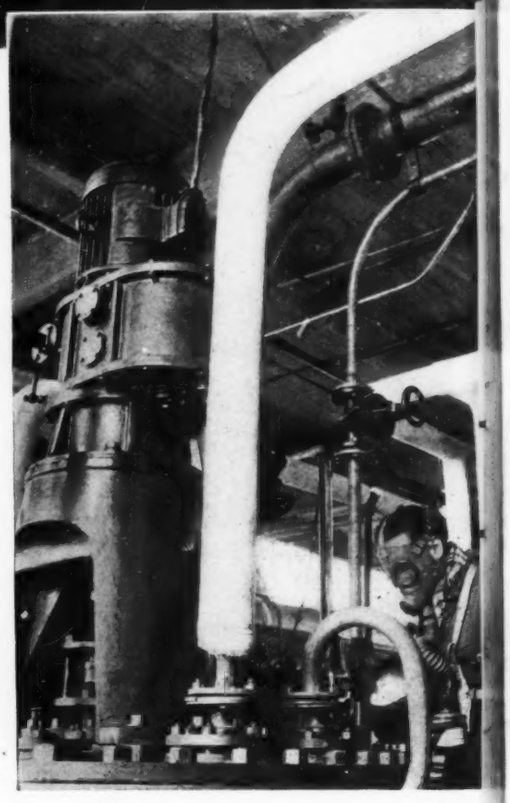
(In Metric Tons)

	GASOLINE			GAS OIL	
Company	Old Quota	New Quota	Alcohol Content	Old Quota	New Quota
A.G.I.P.	102,500	114,491	2,663	49,200	55,149
S.I.A.P.	89,120	99,545	2,315	44,785	50,769
Nafta	66,255	74,005	1,721	59,090	66,895
Petrolea	15,500	17,312	402	9,830	11,156
Aquila	20,000	22,339	519	13,635	15,469
Romana Petroli	2,500	2,793	65	700	789
C.I.P.S.A.	16,000	17,872	416	4,000	4,544
Carburanti Italia	3,000	3,351	78	1,490	1,690
Gardella	3,300	3,686	86	2,165	2,456
Tagliabue	1,000	1,116	25	5,310	6,011
Permolio	5,200	5,808	135	3,405	3,862
Lombarda Petroli	1,900	2,048	48	1,900	2,000
Metaleoi	1,400	1,564	37	—	—
Petroli D'Italia	500	614	14	—	—
S.I.O.	—	—	—	5,750	6,527
A.P.I.	—	—	—	2,250	2,552
Carbol	—	—	—	1,410	1,605

Extensive refinery development has naturally enough made Italy self reliant as to production of refined products, meaning increasing exports of crude oil and smaller purchases of finished products, but adequate supplies of indigenous raw materials are sadly lacking. Ever since the Ethiopian campaign considerable attention had been paid to the problem of substitute fuels.

Production of alcohol for compulsory admixture with gasoline during the year





Supplies of crude oil not yet being obtainable from indigenous shales and lignites, the new A.N.I.C. hydrogenation plant (above) at Livorno, Italy, is at present used to treat East Texas crudes. Right—Conducting research in the A.N.I.C. laboratory at Novara, near Turin.

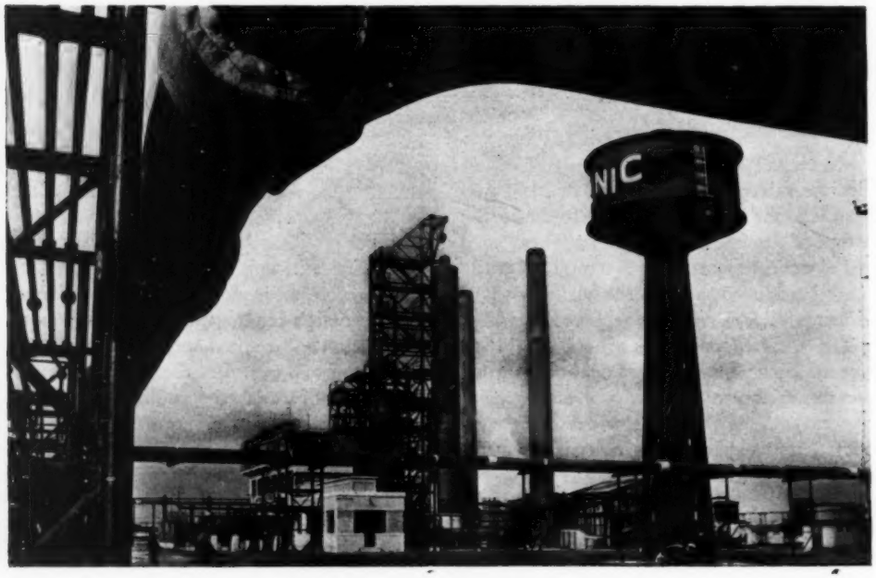
1937-1938 was realized only 70 percent of the planned quota, due to an inadequate crop of sugar beet and its low content in sugar. The result was the decision in January, 1938, to permit the marketing of pure gasoline until further notice. The result has been a change in the official program of national oil economy.

It has been definitely determined that it is possible to produce 120,000 tons of crude from the Albanian oil deposits annually, and 5,000 tons of gasoline from national wells, while a further 12,000 tons of gasoline is obtainable with its replacement by natural gas. Production of alcohol for admixture with gasoline has been temporarily suspended, but the output of crude benzol from coal distillation rose from about 17,000 tons in 1937 to 22,000 tons in 1938. Italy's economists and technologists are still studying the problem of producing the proposed 170,000 tons of oil by treatment of domestic lignites, 100,000 tons from distillation of calcareous asphalts, bitumens and schists, and the replacement of 85,000 tons of gasoline by solid fuel.

In the meantime the total imports of all types of refined petroleum into Italy have been reduced during 1938. The decline was mostly during the last half of 1938, and was due to higher prices occasioned by the increased customs duty. Total consumption during 1937 was officially fixed at 2,138,570 tons of refined oils while that for 1938 was established at 1,751,925 tons—a reduction of about 18 percent. Of this, 921,425 tons were to be produced by domestic refineries and 830,500 tons were to be imported: imports during the previous year were 1,399,670 tons. Thus Italian imports of refined products have been reduced about 40.6 percent.

On the other hand, imports of crude oil have risen considerably, and Italian refineries have been capable of meeting the entire domestic demand for gasoline since the beginning of 1938, as well as about 65 percent of the agricultural and illuminating oil consumption, 75 percent of the lubricating oil required, and the entire demand for white spirit, transformer oil and asphalt.

While production capacity of the Livorno and Bari hydrogenation plants is not indicated, it is noted that the new assignments provide for an addition of 29,745 tons of automobile gasoline and 26,644 tons of gas oil. It may be assumed that these approximate the annual capacity of the two new plants. Below—Distillation section of the A.N.I.C. hydrogenation plant at Livorno.



CHARLES B. BUERGER

CHARLES B. Buerger, vice-president of Gulf Oil Corporation and head of the company's refining operations, died at his home in Pittsburgh, January 3rd, 1939. He had been ill for several months, suffering from a streptococcus infection.

During his service as general manager of Gulf's refining department and later as vice-president in charge of manufacture, Mr. Buerger contributed greatly to the improvement of the company's refinery equipment. He was an early advocate of combination units. He was recognized throughout the industry as an authority on the construction and operation of refineries. Aside from his technical ability his personal qualities attracted a host of friends in trade and technical circles.

U. S. S. R.

Official Figures for Soviet Oil Operation

1938	Production bbl.	Daily Average bbl.	Run to Stills bbl.	Drilling feet
January	17,647,000	569,258	15,882,000	320,000
February	13,591,000	485,393	13,122,000	320,000
March	15,984,000	515,613	14,842,000	340,000
April	17,850,000	595,000	15,850,000	400,000
May	17,580,000	567,097	15,600,000	420,000
June	18,540,000	618,000	15,900,000	550,000
July	18,200,000	587,097	16,800,000	500,000
August	18,000,000	580,645	16,800,000	510,000
September	18,200,000	606,667	16,600,000	500,000
October	18,000,000	580,645	16,600,000	480,000
November	17,600,000	586,667	16,500,000	450,000
Total 11 Mos. 1938	191,142,000	578,584	174,496,000	4,990,000
Total 11 Mos. 1937	185,256,000	554,659	171,103,000	5,724,660
Total 1937	202,856,661	555,772	187,121,389	6,244,660
Total 1936	199,634,921	545,450	180,582,274	6,958,916
Quota 1938	244,215,000*	666,066	215,055,000	not available
Quota 1937	236,450,000	642,329	208,285,000	9,240,000
Quota 1936	222,345,000	607,000	182,250,000	7,100,000

*Crude oil and gas

REPORTS of consultations between Grand Duke Vladimir Cyrilovitch—Czar Vladimir II to Russian monarchists—and Chancellor Adolf Hitler indicate that Germany is preparing for another step in his "Drang nach Osten." According to some, German action in Ukraine is due to start next March and toward the end of June a German-protected Hetmanship of Ukraine will be a reality.

News received indicates that efforts are being made by pro-German agents in forming a free corps of Ukrainians for eventual action against Soviet Ukraine, together with similar bodies of Ukrainian émigrés, Samostinniki, in Germany and elsewhere. They are said to have promised support for an expeditionary force to invade Soviet Ukraine through Ukrainian territory in Rumania and Poland.

Herr Hitler has frequently declared his desire for German domination of Ukraine, only it was not anticipated that he would take action so soon. Persons occupying responsible positions within the White Russian movement believe that he will have Vladimir proclaimed Emperor of all the Russias on condition that Vladimir's brother-in-law, Prince Louis Ferdinand of Prussia, second son of former Crown Prince Friedrich Wilhelm, become regent until Vladimir comes of age, and that a proved pro-German Hetman, or chief, be appointed for Ukraine. Counts Razoumovsky and Skurpatsky have been mentioned as prospects for the post of Hetman.

The major proportion of Ukraine is in U.S.S.R., the smaller in Poland. The population of Soviet Ukraine is about 40,000,000 and enjoys complete automony under the Soviets. The Five Year Plans brought to the Soviet Ukraine extensive industrialization, five times that of prewar days, while it is the granary of Europe. Ukraine plays an important role in Soviet Russia and the unrest under the Communist system is less than in any other part of the U.S.S.R., as nowhere else has the population reaped greater fruits of industrialization than in Soviet Ukraine.

OIL RESERVES

Soviet oil reserves as originally estimated by Prof. I. Gubkin were as follows: Baku, 1,325,000,000 tons; Emba, 640,000,000 tons; Grozni, 138,000,000 tons; Middle-Asia, 240,000,000 tons; Maikop, 82,000,000 tons; and Bashkiria, 60,000,000 tons. Including other possible reserves, the total was about 3,000,000,000 tons, or about 32 percent of the world's total.

Later estimates by Prof. Gubkin have placed Soviet deposits at 6,000,000,000 tons, slightly above 50 percent of the world total, compared with contemporary non-Soviet estimates of 1,600,000,000 tons, or 16 percent of the total for the world.

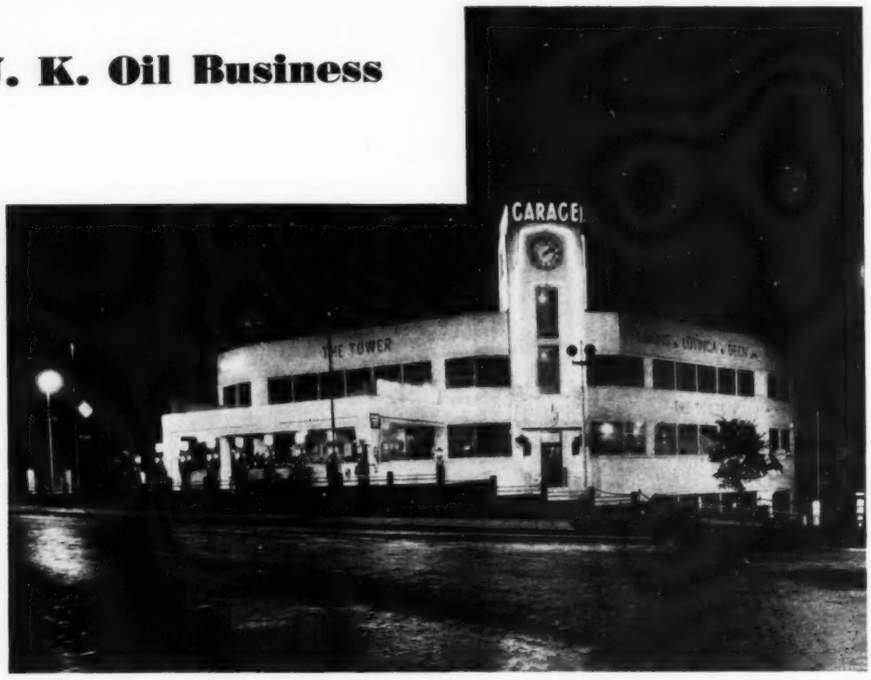
There is no doubt that the Soviet oil deposits are immense, but the various classifications to be found in Gubkin's estimates—including prospected, possible, etc.—show that the figure aforementioned is greatly exaggerated so far as direct application is concerned. The practical value of such estimates, even provided they be based only upon known resources, is limited by the operating conditions. The oil is undoubtedly available, but the Soviets are finding it increasingly difficult to produce it. Soviet Russia now ranks second as producer, with about 11 percent of the world's output, and also stands as the second largest consumer—in fact, the country even finds it necessary to import gasoline from the United States.

J. WEGRIN

PARADOX in U. K. Oil Business

By Alec H. Day

British Petroleum Companies May Show Lower Earnings for 1938 Despite Increased Turnover Due to Marketing Policy.



Outstanding example of progress—gasoline service station and garage in England.

ANNUAL accounts of British oil companies for 1937 published during 1938 confirmed the favorable forecast published in WORLD PETROLEUM a year ago. Increased earnings have been published by the majority of leading concerns, the improvement being substantial in many cases. Profit declines have been few in number and small in extent. Results have reflected profitable conditions for oil production and distribution in 1937, but meanwhile, actual conditions in the industry have taken a turn for the worse.

Ultimately, profits of the great majority of British oil companies are dependent on the United States price structure more than any other single factor. Weakening of United States conditions is therefore bound to affect British earning capacity. But there is no ground for assuming that severe reductions in profits will be shown for 1938. If oil prices are less favorable, other factors should have tended to counteract the effect on profits. Two important considerations are improvement in turnover and the rise in the value of the U.S. dollar in terms of sterling.

These general factors may be applied in some degree to most British oil undertakings, but provide no certain index of the fortunes of any individual company during 1938. Operations of British concerns are so diverse that each undertaking may be placed in a category by itself.

Diversity of interest is revealed by the fact that some concerns produce their own oil and market it through their own organization or associates in Britain. Some sell crude on the basis of United States prices, and most are dependent partly on financial conditions in their areas of production and on marketing conditions in the countries where they distribute. This leaves out of account companies like Attock, where the result of developments may have a major effect on profits, and big integrated concerns like Shell Transport operating in every quarter of the world.

With operations so diversified, no general rule can be laid down for judging probable results, for no one set of circumstances can govern the experience of more than a few companies.

Conditions in Britain itself during the year suggest that turnover of companies distributing there has been larger, but profit margins smaller. The retail price of first-grade gasoline stood at the beginning of 1938 at 1s. 7d. per gal., but was cut on February 18th to 1s. 6½d. Increase of 1d. in the Government tax to 9d. per gal. in the budget brought about a rise in the price to 1s. 7½d., but the quotation was cut again to 1s. 7d. on May 13th. Average price for the year is thus 1s. 6.9d., or 10.2 d., after deducting average tax of 8.7 d. This compares with 1s. 7d. and 11d. respectively for 1937, when tax was 8d.

On balance, retail prices of motor spirit show no change on the year, but as the tax has been raised by 1d. per gal., the net price to the distributing organizations has declined from 11d. to 10d.

This change practically coincides with the reduction in the cost and freight on motor spirit brought from the Gulf. If 64-66 spirit is taken as an example, the January 1st quotation was 5¼ c. per U.S. gal., equivalent at the exchange then ruling to approximately 3d. per Imperial gal. The December Gulf price of 4⅜ c. at the December exchange is equal to around 2¾d., a fall of about ¼d. per Imperial gal.

Meanwhile clean tanker freights from the Gulf have come down from 32s. 6d. to 12s. 6d. per ton, the decline representing approximately ¾d. per gal. If other costs of transport and distribution are taken as unchanged, the fall in costs and selling prices is practically the same. This position reflects the policy of the major companies of keeping the British motor spirit market on a practically unremunerative basis to the purchaser of spirit abroad for distribution in Britain.

There is little hope of improvement in British margins while present price policy remains. Although in many respects a favored market, Britain is evidently being kept in an unremunerative state by the major companies. That policy is the result either of fear that the smaller independent concerns will unduly increase their sales, or that some new competitor will come into the market.

The spectre of petroleum competition has now been walking in Britain far too long. Experience to-date suggests that until there is a definite change of policy, distributors will continue to work for exceedingly small profit, and often for no profit at all.

Aside from tax, the sales price of first grade spirit sold by the major companies has to bear a rebate to retailers, and a profit to the retailer has to be allowed by all importers and distributors. In addition, a large part of the total spirit marketed in Britain consists of lower priced commercial grades, of which a considerable portion is

delivered under contract at highly competitives prices. These factors, according to London oil men, practically eliminate the profit per average gallon of gasoline sold in the British market.

Published quotations for other products have followed the downward course of the American market. Changes during the year in some of the widely marketed categories are set out in the accompanying table.

United Kingdom Oil Prices In 1938

Per Imperial gallon

	Jan. 1	July 1	Dec. 1
Kerosene: best quality (wholesale)	8¼d.	8d.	8d.
Gas oil (bulk)	4¾d.	4¾d.	4¾d.
Road Diesel oil (bulk)	1s. 1¼d.	1s. 2d.	1s. 2d.
Road Diesel oil ex tax	5¼d.	5d.	5d.
Fumess oil .950 gravity (bulk)	3¾d.	3¾d.	3¾d.
		(per ton)	
Lube oils: American pales (bulk)	£13⅛-22⅜	£12¾-22¾	£11¼-21

The rise in the selling price of Diesel engine oil for road vehicles is accounted for by the rise in the tax by 1d. per gallon concurrently with the raising of the motor spirit duty. As shown by the ex tax price, the net figure received by distributors actually fell during the first half year by ¼d. per gal.

Price movements in these products are much in alignment with lower import prices, but, like the fall in the price of motor spirit, a lower price level means so much less profit to most distributors in Britain. Where a company produces in its own field or that of a subsidiary, and provides for ocean transport within its own group, the American price level can have little effect on costs; but it affects profits nevertheless, by reducing selling quotations.

Releases of hydrocarbon oils for domestic consumption, announced by the U. K. Customs, suggest that if profit margins in Britain have been low, and competition keen, these factors have been offset to some extent by a larger turnover. Total releases for the first nine months of 1938 amounted to 47,154,000 bbl., an increase of 1,004,000 bbl., or 2.2 percent, over the corresponding period of 1937.

Intensified importation, due to the European crisis in September, contributed to the increase, but the 1938 figures had been running throughout at above those for 1937, and the larger scale of operations should have given distributors some compensation for lower prices.

Improvement in the sterling value of the dollar will have had an influence on the earnings of many British oil concerns. Companies selling their output on a dollar basis should have gained some advantage. Those with operating costs in dollars or in South American currencies based on the dollar, will have been affected to a somewhat smaller extent.

Conditions in the Indian market have been relatively good during the first half of the year, and Sir John Cargill, speaking at the Burmah Oil Company's meeting in June, gave a moderately encouraging account of the outlook. His view may apply more to the strong position of the Burmah Company than to the Indian market generally.

Having regard to the political shocks to which the London Stock Exchange has been subjected, prices for oil shares have been well maintained and most yields, set out in the accompanying table, show relatively little alteration against a year ago. The only exception is provided by Lobitos, where the high return suggests doubt as to the maintenance of the dividend at the rate to which it has been raised. The substantial drop in the Burmah price is explained by the distribution of a 50 percent share bonus during the year.

That yields have not risen further, despite general depression on London markets, may be attributed as much to confidence in the financial strength of the individual companies concerned as to belief in the current stability of the oil industry.

British Oil Share Market

	December 15, 1937			December 15, 1938		
	Price £	Dividend % (a)	Yield %	Price £	Dividend % (a)	Yield %
Anglo-Iranian	4	25	6.2	4 ⅜	25*	5.6
Burmah Oil	5 ⅜	27½	4.7	4 ⅞‡	30	7.2
Lobitos Oilfields	2	12½	6.2	1 ⅞	15	10.4
Shell Transport & Trading	4 ⅜	20#	4.2#	4 ⅞	20#	4.9#
Trinidad Leaseholds	5⅛	30	5.9	4 ⅜	27½	6.0

(a) Including cash bonus if any.
* Paid on capital as increased by share bonus
‡ Share bonus 50 percent issued during year.
# Tax free.

INDIAN OIL CONCESSIONS

ON OCTOBER 10th, 1938, Indian Oil Concessions, Ltd., in which Standard Oil Company of California and The Texas Corporation through their subsidiaries hold a major interest, obtained a prospecting license covering the State of Bahawalpur in the upper Indus Valley. The area covers approximately 16,430 sq. mi. and is the principal Mohammedan state of the Punjab. It runs more than 300 mi. along the left bank of the Indus and Sutlej rivers.

Indian Oil Concessions, Ltd., was organized October 8th, 1937, to acquire concessions and carry on exploration in India. Capitalization is 200,000 Rupees ($70,000) with headquarters at Calcutta and field office at Karachi, the capital of Sind at the mouth of the Indus River. The stock of the company is held through subsidiaries of the Standard Oil Company of California and The Texas Corporation and by British interests.

GULF EXPORT PRICES FOR MAJOR OIL PRODUCTS

Products		Dec. 21	Dec. 28	Jan. 4	Jan. 11
		Cents Per Gallon			
GASOLINE:	U.S. Motor	4⅜	4⅜	4⅜	4⅜
	64/66-375 E.P.	4⅜	4⅜	4⅜	4⅜
	59 Octane and below	4¼	4¼	4¼	4¼
	65 Octane and above	4⅝	4½	4½	4½
AVIATION GASOLINE:	Gulf Export in cargo lots	8¼	8¼	8¼	8¼
KEROSENE:	44 w.w.	4⅛	4⅛	4⅛	4⅛
	41/43 w.w.	3⅞	3⅞	3⅞	3⅞
	41/43 p.w.	3⅞	3⅞	3⅞	3⅞
GAS OIL:	43 Diesel Index and below	3⅜	3⅜	3⅜	3⅜
	43/47 Diesel Index	3⅝	3½	3½	3½
	48/52 Diesel Index	3½	3½	3½	3½
	53/57 Diesel Index	3⅝	3⅝	3⅝	3⅝
		Dollars Per Barrel			
FUEL OIL:	Bunker C	75	75	75	75
	Cargo lots	67½	67½	67½	67½
	Diesel oil	1.55	1.55	1.55	1.55
		Cents Per Gallon			
LUBRICATING OIL:	Bright Stock No. 8	19½	19½	21½	21
	Bright Stock No. 6½	21½	21½	21½	21½
	600 Warren E.	20½	20½	20½	20½
	600 Unfiltered s.r.	15½	15½	15½	15½
(New York Export Market)	650 Unfiltered s.r.	16½	16½	16½	16
	600 Flash s.r.	17½	17½	17½	17½
	630 Flash s.r.	19½	19½	20½	20½
	Neutral 200 No. 3	22½	22½	22½	22½
	Neutral 150 No. 3½	20½	20½	20½	20½
(South Texas Export Market)	Red oil 500 No. 5-6	7½	7½	7½	7½
	750	8	8	8	8
	1200	8⅜	8¾	8⅜	8⅜
	Pale oil 500	7½	7½	7½	7½
	750	8	8	8	8
	1200	8⅜	8⅜	8⅜	8⅜
		Dollars Per Barrel			
CRUDE OIL:	East Texas delivered at Gulf for export	1.25	1.25	1.25	1.25

Foreign Oil Legion

Abdel Hameed el Difrawi Effendi, M.Sc.

ABDEL HAMEED EL DIFRAWI EFFENDI, M.Sc., has been appointed to take control of the government oil refinery at Suez, being the first Egyptian to succeed DR. M. B. BLACKLER, who recently retired. He was selected in 1923 for an Egyptian government mission to study petroleum engineering at the University of California and to return to be affiliated with the mines department as technologist. With the idea of gaining practical experience he spent a year in the Ponca City refinery of Marland Oil Company, while a further 12 months in the field studying drilling and production problems completed his experience in the United States. In 1929 he returned to Cairo as assistant inspector of the mines department. He was put in charge of geophysical work for oil exploration in the Red Sea area, and in charge of the petroleum office in Cairo. In 1934 he was transferred to Suez as submanager of the government refinery, and in September last was made manager.

MAURICE GRELARD, director of Société Huni Mirabaud, marketers of fuel oil in France, returned to Paris on board the liner CHAMPLAIN December 2nd, after a trip to the United States.

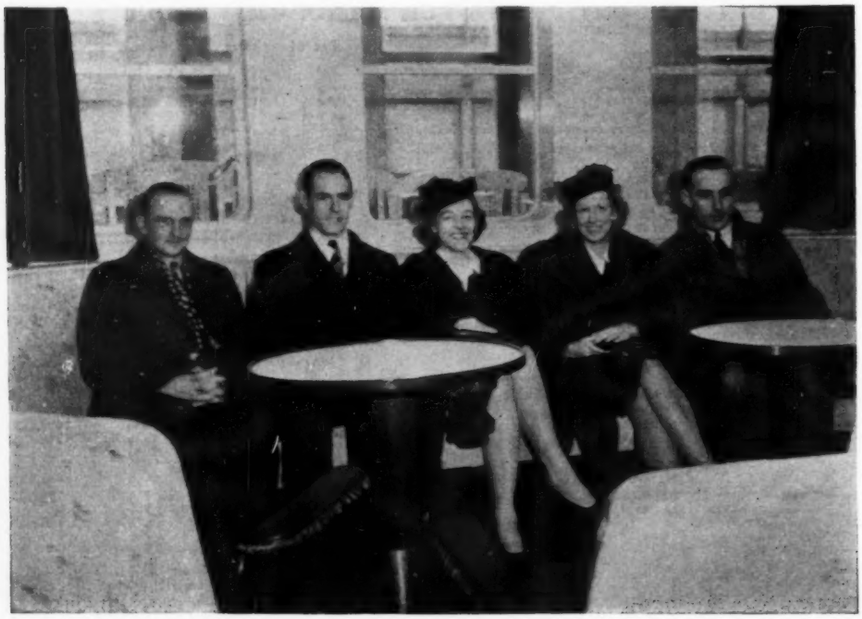
W.P. Staff Photo

Commander Sergius M. Riis being interviewed in the office of the editor of World Petrolum.

FIELDER J. COFFIN, director of the foreign department of Sun Oil Company of Philadelphia, returned from London on board the QUEEN MARY, arriving in New York December 1st. Mr. Coffin had been making an extensive business trip to Continental countries.

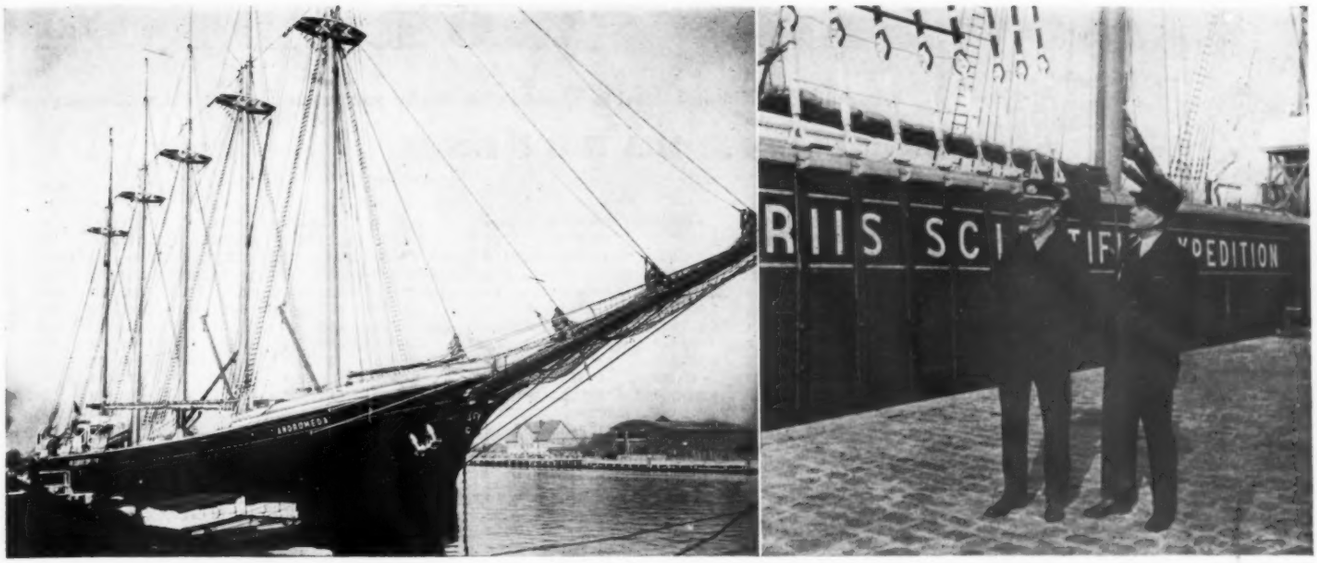
Three United States geologists left New York on the Noordam December 10th, accompanied by their wives, and flew by K.L.M. plane from Amsterdam, Netherlands, on December 24th to Karachi, India. From left to right: D. A. Fullerton, Stanford Rose, Mrs. Rose, Mrs. Ramsden, and C. H. Ramsden. Stan Rose and Don Fullerton have worked previously in the Rocky Mountain area, while Chuck Ramsden has spent several years in Colombia and the Maracaibo basin, Venezuela. They will be three years with Indian Oil Concessions Ltd.

W.P. Staff Photo



Herbert Leslie

HERBERT LESLIE, A.S.M.E., formerly chief engineer for Standard Oil Company of Brazil, has returned from New York to Rio de Janeiro where he is now established as consulting engineer for the petroleum industry of that country. Mr. Leslie, who has been in the employ of Jersey Standard for 20 years, is also well-known in Venezuela.



Left—The five-masted auxiliary schooner Andromeda (named after one of the first oil-carrying vessels to cross the Atlantic) which is being held in Germany as a result of the dispute over a contract to carry a cargo of cellulose to Wisconsin. Right—Commander Riis with his captain, Bendik Johannsen, who was ice pilot on both of Admiral Byrd's expeditions to the Antarctic. The consigner attempted to cancel the contract after the cargo was loaded aboard the Andromeda and secured the support of the local courts, which ordered the American master to unload. When Commander Riis refused, the German authorities took off the cargo by force and imposed fines and costs totalling $10,500. It was with this vessel that Commander Riis planned to collect data to disprove the generally accepted belief that the earth's axis is inclined to the plane of its orbit. He contends that it is the plane of the orbit that is inclined.

COMMANDER SERGIUS M. RIIS, explorer, shipmaster and ex-oilman, is in New York in connection with the release of his schooner ANDROMEDA which is being held by the German authorities at Koenigsberg. He describes the proceedings as holding his ship for ransom, and has asked the American State Department to save her until he can raise funds to bail her out.

Commander Riis has had a varied and active career—at 23 he shipped as assistant navigator on the polar relief ship TERRA NOVA which rescued the Zeigler Polar Expedition of 1903, headed by Major Anthony Fiala. He became a lieutenant of marines in 1907 and served in the intelligence section until 1917-1918, when he was part of the U.S. mine squadron which layed the wartime barrage across the North Sea.

It was in 1923 that Commander Riis entered the oil industry as a lubrication specialist in China for one of the major American oil companies, remaining until 1927. During this period he facilitated the sales of his company's products by acting as naval advisor to Chang Tso-Ling in return for making his purchases from that company only. Most of the commander's activities were in Manchuria, where he was in charge of the installation at Harbin as well as that at Canton, in South China. He also made trips into the interior near the border of inner Mongolia.

On one of these trips he was going to collect payments from the agent at the town of Sin-Lin-Tun, in the interior. As he left the railroad he sought the advice of the local headman who warned him against the journey; when he insisted upon continuing, Commander Riis was offered an armed guard of 50 men, for a nominal fee.

The journey was several hundred miles, and when they had traversed about half the distance the leader of the party called a halt informing him there was a bandit encampment ahead some 4,000 strong and that it could not be hoped to beat them in a pitched battle.

It was agreed to negotiate with them for a safe passage and the leader left with a few others, not returning for four days. When they came back he said that the bandit chief wished to see the American—alone. Commander Riis asked as to what could be accomplished without his interpreter, as he did not speak Chinese, but was informed that the bandit was familiar with the English language.

Upon arrival in the encampment Commander Riis learned to his surprise that the chief was a graduate of Columbia University and had turned to banditry as the best means of earning a living. The commander pointed out that under no circumstances would his company pay ransom, so the chief offered to supply a guard of 100 men for half the price of the original guard. Commander Riis replied "How about twice as many for the same sum?"

With his guard of 200, and about 25 coolies to carry the supplies, Commander Riis arrived safely at the outpost and was greeted warmly by the agent. Now his worry was how to get back without the bandits learning about the large sum of money he was carrying. The agent said to leave it to him and he'd have the money when he got to the rail-head.

The journey back was uneventful, except for the manner in which the bandits fraternized with the villagers upon their return and proved that they had been in league all along. When they got there Commander Riis was advised that the money was sewed in the lining of his coolies' clothes—unknown to the bandits, to the coolies or even to himself!

It was wintertime and the money had not been noticed in the thick garments.

Leaving China, Commander Riis joined the sales organization of the old Standard Nobel concern—then a branch of Jersey Standard—as lubrication expert from 1927 to 1932, during which time he made an exhaustive study of turbine oils.

In 1932 he married and purchased a three-masted schooner, which he later sold to buy a four-masted vessel of the same type. Until recently he had been sailing from Baltic ports to the Mediterranean and more recently in the West Indies, carrying freight as a side-line to pay the expenses of his chief interest—exploration and scientific research.

It was the first cargo of the ANDROMEDA, which he bought in June, over which the dispute arose.

WORLD OIL

All figures furni.hed direct to WORLD PETROLEUM by governments, except where otherwise specified

U. S. BARRELS

	December 1937	January 1938	February 1938	March 1938	April 1938	May 1938	June 1938	July 1938	August 1938	Sept. 1938	Oct. 1938	Preliminary Figures Nov. 1938
United States	106,579,000	106,007,000	94,662,000	106,524,000	102,702,000	98,674,000	94,277,000	102,898,000	106,165,000	98,661,000	101,830,000	**100,400,000**
Soviet Union[4]	17,600,000	17,647,000	13,591,000	15,984,000	17,850,000	17,580,000	18,540,000	18,200,000	18,000,000	18,200,000	18,000,000	**17,600,000**
Venezuela	17,096,298	15,271,902	13,792,479	15,109,040	13,696,219	15,994,400	16,302,150	14,912,555	16,616,673	16,271,096	17,352,171	**16,600,000**
Iran[5]	5,999,642	5,907,458	6,414,470	8,284,215	7,090,486	6,975,256	5,792,228	5,338,990	5,861,366	5,676,998	5,860,000[1]	**5,670,000**
Netherland India: Sumatra	4,671,582	2,674,572	2,587,988	2,912,764	2,809,415	2,971,443	2,893,856	2,814,237	2,901,321	2,917,167	3,049,196	**2,920,000**
Borneo		1,123,800	1,008,290	1,114,431	1,056,224	1,066,281	1,013,163	1,061,980	970,690	1,069,872	1,123,102	**1,070,000**
Java[9]		637,102	590,763	643,568	639,582	674,927	616,845	585,086	524,384	482,417	523,623	**482,000**
Ceram		53,215	48,388	50,377	52,329	51,524	49,870	54,035	54,825	50,355	50,444	**50,000**
Roumania	4,198,000	4,099,000	3,751,692	4,182,000	4,090,000	4,169,000	4,015,000	4,115,000	4,075,736	3,915,029	4,028,750	**3,910,000**
Mexico	4,349,415	4,141,977	4,016,000*	1,926,368*	1,912,493*	2,301,995*	2,374,815*	2,000,000[1]	2,300,000[1]	3,250,000[1]	3,500,000[1]	**3,250,000**
Iraq	2,431,532	2,670,844	2,385,464	2,717,278	2,592,996	2,332,746	2,653,579	2,806,903	2,829,528	2,621,547	2,431,949	**2,420,143**
Colombia	1,824,956	1,784,638	1,508,487	1,841,882	1,642,195	1,819,689	1,826,136	1,826,848	1,870,013	1,797,158	1,891,825	**1,845,000**
Trinidad	1,349,908	1,378,021	1,304,819	1,438,436	1,418,825	1,481,285	1,431,476	1,500,171	1,505,959	1,514,893	1,594,480	**1,515,000**
Argentina[1]	1,370,000	1,378,000	1,289,000	1,380,000	1,349,000	1,382,000	1,346,000	1,349,000	1,360,000	1,358,000	1,360,000	**1,358,000**
Peru[3]	1,486,121	1,365,152	1,224,437	1,474,364	1,296,090	1,343,259	1,303,536	1,335,623	1,328,143	1,280,691	1,331,111	**1,303,990**
Bahrein[6]	805,236	805,800	707,379	737,164	692,403	620,746	661,602	699,176	713,149	714,349	708,962	**714,000**
Burma[7]	640,195	616,522	496,306	633,644	635,903	667,346	679,368	638,000[1]	635,000[1]	650,000[1]	635,000[1]	**650,000**
Brunei[8]	405,623	409,592	381,052	445,194	428,829	445,505	425,184	453,393	448,219	478,080	477,459	**478,000**
Canada[2]	408,580	457,408	413,158	480,803	464,316	566,086	537,654	693,332	817,706	886,111	685,088	**886,000**
Great Germany: Old Reich[14]	277,551	268,028	257,967	355,684	342,387	329,688	326,842	346,435	342,484	328,098	331,792	**328,000**
Ostmark[15]	20,850	25,620	28,160	30,070	29,100	32,845	30,000[1]	31,062	29,453	29,000[1]	43,697	**29,000**
Poland	325,940	318,928	293,232	327,077	315,768	324,803	315,381	314,000[1]	328,115	321,134	326,000[1]	**318,000**
Japan[10]	211,436	218,594	214,191	214,820	207,522	216,078	216,707	216,707	217,525	170,597	220,451	**226,000**
Ecuador	178,776	187,525	171,138	191,746	181,331	190,542	188,712	192,360	193,634	189,037	192,702	**185,669**
British India[11]	210,360	196,697	132,164	197,792	196,543	198,872	192,656	195,000[1]	200,000[1]	197,800[1]	195,000[1]	**198,000**
Saudi Arabia	2,685	2,523	4,155	2,622	2,382	3,794	3,477	3,550	3,459	40,556	136,947	**152,632**
Sarawak[12]	131,901	137,497	126,578	137,281	133,248	137,824	132,240	132,007	107,102	123,476	223,165	**123,000**
Egypt[13]	94,509	91,927	84,974	94,545	88,555	89,935	84,998	83,412	143,978	157,533	208,377	**200,000**
Albania[16]	No Data	42,400	39,200	42,400	41,000	42,400	72,300	46,049	4,998	68,655	48,000[1]	**42,000**
France	42,368	41,560	40,840	43,589	42,839	48,545	43,189	43,574	43,000[1]	41,104	43,000[1]	**42,000**
Hungary	11,980	13,744	12,461	13,976	13,775	18,691	26,018	25,888	30,900[1]	41,000[1]	49,800[1]	**52,000**
Czechoslovakia	11,734	11,070	10,437	12,158	10,731	10,960	10,159	9,333	11,015	10,933	13,747	**11,000**
Bolivia	12,810	10,302	7,128	9,100	8,800	9,000	8,790	9,500	9 200[1]	8,500[1]	8,800[1]	**8,500**
Italy	8,493	9,048	7,969	9,612	9,459	9,563	8,646	9,378	9,057	8,267	7,000[1]	**7,000**
Other Countries[17]	6,000	6,000	5,400	6,000	5,800	6,000	5,800	6,000	6,000	50,000	48,000	**50,000**
WORLD TOTAL	172,763,481	170,010,466	151,609,166	168,898,000	164,048,545	162,787,023	158,405,367	168,952,818	170,657,632	163,580,453	168,499,638	**165,394,934**

[1] Estimate.
[2] Includes natural gasoline production.
[3] International Petroleum Company and Lobitos Oilfields Ltd. figures combined.
[4] Russian Sakhalin included with U.S.S.R.
[5] Anglo-Iranian Oil Company Ltd. figures revised—fuel oil returned to the ground has been deducted.
[6] Bahrein Petroleum Company Ltd. figures.
[7] Does not include Assam or Punjab, which are listed together under British India.
[8] British Malayan Petroleum Company Ltd. figures.
[9] Includes Madura.

Official Crude Oil Production Figures for 1932 to 1937 (Revised)

	Daily Av. Jan.-Nov. 1938	Daily Av. Jan.-Nov. 1937	Total Jan.-Nov. 1938	Total Jan.-Nov. 1937	Total 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	**3,331,537**	3,510,721	**1,112,800,000**	1,172,581,000	1,279,160,000	1,098,516,000	996,596,000	908,065,000	905,656,000	785,159,000
Soviet Union	**572,431**	551,666	**191,192,000**	184,256,661	201,856,661‡	199,635,921	184,008,033	175,635,783	155,596,429	155,927,997
Venezuela	**469,002**	510,716	**156,646,733**	170,579,179	187,675,477	155,270,840	148,809,057	136,098,681	117,113,940	115,615,782
Iran	**206,200**	215,896	**68,871,467**	72,109,359	65,281,636	62,977,950	57,520,488	57,902,092	54,440,075	49,516,697
Netherland India: Sumatra	**94,167**		**31,451,959**		33,451,511	30,469,428	28,004,595	26,336,011	22,345,172	18,570,928
Borneo	**34,963**	147,995	**11,677,833**	49,430,368	12,960,072	13,068,910	13,529,185	14,335,543	15,003,175	15,228,615
Java	**19,162**		**6,400,297**		7,152,931	3,618,293	3,462,440	3,778,920	3,600,816	3,837,142
Ceram	**1,692**		**565,362**		537,436	375,823	311,872	273,698	285,335	309,957
Roumania	**132,788**	144,304	**44,351,207**	48,197,725	52,395,725	63,532,846	61,270,072	61,849,306	53,919,708	53,651,978
Mexico	**90,659**	126,066	**30,273,648**	42,106,272	46,455,687‡	41,027,915	40,240,563	38,171,946	34,000,830	32,805,496
Iraq	**85,218**	84,347	**28,462,977**	28,172,128	30,603,660‡	29,913,150	27,410,983	7,639,849	1,094,915	871,840
Colombia	**58,843**	55,307	**19,653,871**	18,472,587	20,297,543‡	18,756,110	17,597,655	17,337,900	13,156,126	16,415,214
Trinidad	**48,153**	42,374	**16,083,365**	14,153,081	15,502,989	13,237,030	11,671,224	10,894,363	9,561,353	10,126,121
Argentina	**44,458**	44,864	**14,909,000**	14,984,717	16,354,717	15,457,960	14,297,025	14,021,901	13,690,556	13,138,747
Peru	**43,654**	47,823	**14,586,396**	15,972,991	17,459,112	17,593,069	17,056,555	16,314,381	13,257,318	9,899,265
Bahrein	**23,277**	20,829	**7,774,730**	6,957,028	7,762,264	4,644,635	1,264,807	285,072	31,377	902
Burma	**20,769**	21,579	**6,937,089**	7,207,358	7,847,553	7,587,718	7,181,113	7,278,859	7,114,311	7,073,437
Brunei	**14,582**	11,950	**4,870,507**	3,991,415	4,397,038	3,296,938	3,302,905	2,705,350	2,035,656	1,200,026
Canada	**20,621**	7,474	**6,887,662**	2,496,445	2,995,025	1,507,931	1,447,204	1,410,895	1,145,333	1,044,412
Great Germany: Old Reich	**10,631**	8,595	**3,557,405**	2,870,749	3,148,300	3,076,858	2,967,438	2,204,402	1,656,602	1,594,807
Ostmark	**1,011**	656	**338,007**	219,181	221,266	50,092	44,347	27,965	5,765	804
Poland	**10,486**	10,401	**3,502,458**	3,473,922	3,799,862	3,869,575	3,901,881	4,011,336	4,174,079	4,219,634
Japan	**7,003**	6,815	**2,339,192**	2,276,405	2,487,841	2,403,072	2,294,878	1,872,837	1,504,412	1,683,439
Ecuador	**6,180**	5,936	**2,064,396**	1,982,660	2,161,436	1,942,467	1,731,785	1,636,619	1,619,902	1,597,641
British India	**6,288**	5,842	**2,100,524**	1,951,293	2,161,653	1,978,329	2,037,810	1,921,863	1,628,803	1,743,878
Saudi Arabia	**1,062**	186	**356,097**	62,283	64,968	19,777	Nil	Nil	Nil	Nil
Sarawak	**4,531**	4,562	**1,513,418**	1,523,664	1,655,565	1,547,882	1,776,593	1,942,591	2,206,815	2,329,733
Egypt	**3,959**	2,401	**1,328,234**	1,068,758	1,163,267	1,252,666	1,255,151	1,527,252	1,653,535	1,071,976
Albania	**1,465**	1,646	**489,402**	550,000	591,677‡	219,693	41,218	17,500	11,437	9,212
France	**1,416**	1,391	**473,240**	464,699	507,067	534,063	529,664	700,000	786,366	755,146
Hungary	**891**	6	**298,253**	1,930	13,910	100	Nil	Nil	Nil	Nil
Czechoslovakia	**363**	331	**121,543**	110,493	122,790	126,603	136,580	177,797	121,695	126,603
Bolivia	**292**	333	**97,620**	111,372	123,123	104,746	163,295	157,875	111,973	41,907
Italy	**284**	321	**94,999**	107,236	115,801‡	129,653	128,615	162,449	213,534	242,563
Other Countries	**584**	192	**195,000**	64,200	70,000	37,100	32,300	64,000	54,100	73,300
WORLD TOTAL	**5,362,441**	5,545,702	**1,764,153,596**	1,853,520,512	2,027,047,665	1,797,891,143	1,652,023,331	1,516,760,036	1,438,797,443	1,305,574,242

‡Preliminary.

PRODUCTION

Figures in U. S. barrels of 42 gal.—Conversion ratios used are weighted averages for individual countries

METRIC TONS

	Dec. 1937	Jan. 1938	Feb. 1938	March 1938	Apr. 1938	May 1938	June 1938	July 1938	Aug. 1938	Sept. 1938	Oct. 1938	Preliminary Figures Nov. 1938
United States	14,427,914	14,345,022	12,814,670	14,420,469	12,916,610	13,357,804	12,762,583	13,939,606	14,507,243	13,189,481	13,785,028	13,590,000
Soivet Union[4]	2,410,000	2,421,000	2,440,000	2,192,000	2,448,000	2,411,000	2,543,000	2,497,000	2,470,000	2,497,000	2,470,000	2,414,000
Venezuela	2,526,422	2,256,820	2,038,197	2,232,753	2,023,972	2,363,588	2,409,066	2,205,195	2,455,545	2,404,477	2,564,234	2,450,000
Iran[5]	793,496	781,304	848,360	1,095,647	937,768	922,528	766,064	706,120	775,208	750,824	760,000[1]	750,000
Netherland India: Sumatra	627,058	359,003	347,381	390,975	378,445	398,988	388,437	377,750	389,439	391,566	409,288	392,000
Borneo		150,847	135,341	149,588	141,775	143,124	135,995	142,549	130,294	143,607	150,752	144,000
Java[6]		85,517	79,297	86,385	85,850	90,460	82,798	78,535	70,387	64,754	70,285	65,000
Ceram		7,143	6,495	6,762	7,024	6,916	6,694	7,253	7,359	6,759	6,771	6,700
Roumania	575,068	559,973	512,175	570,239	558,362	568,874	548,139	561,775	556,415	534,475	550,000	534,000
Mexico	647,196	614,902	596,200*	182,061*	283,921*	341,745*	352,555*	297,000[1]	355,000[1]	482,500[1]	519,600[1]	482,500
Iraq	326,030	358,118	319,853	364,344	347,948	312,771	355,803	376,415	379,395	351,508	326,086	324,503
Colombia	254,349	248,730	210,242	256,700	228,878	253,615	254,514	254,669	260,629	250,475	263,669	257,000
Trinidad	189,967	193,923	183,622	202,425	199,666	208,456	201,446	211,113	211,928	213,185	224,385	213,200
Argentina[1]	195,000	196,300	183,600	198,000	192,200	196,900	191,900	192,200	193,800	193,500	194,000	193,500
Peru[5]	196,942	180,911	162,263	195,383	171,759	178,010	172,745	168,795	176,006	167,718	177,893	172,805
Bahrein[6]	110,186	109,751	95,450	100,478	94,457	84,723	90,435	95,498	97,279	97,479	96,660	97,400
Burma[7]	88,388	85,120	69,240	91,765	87,796	92,275	93,797	87,900[1]	87,800[1]	89,100[1]	87,800[1]	89,100
Brunei[8]	53,110	54,623	49,965	58,376	56,230	58,416	55,552	59,464	58,772	62,688	62,607	62,700
Canada[9]	51,614	57,783	52,193	60,739	58,649	71,511	67,934	87,586	103,298	111,686	86,545	111,600
Great Germany: Old Reich[14]	39,977	38,604	37,155	51,517	49,314	47,485	47,075	49,897	45,007	47,256	47,788	47,200
Ostmark[15]	2,850	5,816	5,253	5,820	5,627	4,900	5,800[1]	4,634	4,394	5,600[1]	6,519	5,600
Poland	43,000	42,075	38,685	43,150	41,658	42,850	41,607	41,000[1]	43,287	42,366	43,000[1]	42,000
Japan[10]	30,089	30,070	30,481	30,586	29,518	30,750	30,839	30,839	30,955	24,277	31,376	32,000
Ecuador	25,377	26,577	24,254	27,175	25,699	27,004	26,743	27,262	27,412	26,791	27,310	26,314
British India[11]	29,040	27,157	18,247	27,308	27,136	27,357	26,599	27,000[1]	27,600[1]	27,300[1]	27,000[1]	27,300
Saudi Arabia	345	323	516	328	305	492	451	460	453	5,498	18,570	20,697
Sarawak[12]	17,270	18,337	16,597	18,001	17,472	18,072	17,340	17,309	13,913	16,191	16,150	16,200
Egypt[13]	13,511	13,365	12,005	13,516	12,660	12,642	12,151	11,924	20,583	22,521	29,789	21,500
Albania[16]	No data	6,200	5,650	6,200	6,060	6,200	10,790	6,873	746	10,247	7,000[1]	6,200
France	5,933	5,820	5,579	6,104	5,999	6,798	6,048	6,102	6,000[1]	5,756	6,000[1]	5,900
Hungary	1,550	1,778	1,612	1,808	1,782	2,418	3,366	3,349	4,000[1]	5,300[1]	6,400[1]	6,700
Czechoslovakia	1,714	1,617	1,526	1,776	1,566	1,601	1,484	1,521	1,609	1,597	2,008	1,600
Bolivia	1,611	1,295	897	1,140[1]	1,110[1]	1,130[1]	1,100[1]	1,200[1]	1,160[1]	1,000[1]	1,100[1]	1,000
Italy	1,055	1,124	990	1,194	1,175	1,188	1,074	1,164	1,125	1,027	1,000[1]	1,000
Other Countries[17]	900	850	770	850	830	850	830	850	850	7,000	6,700	7,000
WORLD TOTAL	23,686,9 2	23,287,788	21,344,763	23,091,564	21,441,537	22,293,441	21,512,754	22,567,667	23,514,891	22,252,653	23,083,313	22,617,819

[10] Japanese Sakhalin, Taiwan (Formosa) and Hokkaido included with Japan.
[11] Excluding Burma.
[12] Sarawak Oilfields Ltd. figures.
[13] Anglo-Egyptian Oilfields Ltd. figures.
[14] Prussia, Thuringia and Baden.
[15] Formerly known as Austria.
[16] Italian imports of Albanian crude oil.
[17] Nominal figure representing proportion to world total represented by: Morocco, Cuba, New Zealand, Barbados, Greece, Algeria, Yugoslavia, Australia, Great Britain, Kuwait and China.
* Official Figures—Petroleos Mexicanos.

Official Crude Oil Production Figures for 1932 to 1937 (Revised)

	Daily Av. Jan.-Nov. 1938	Daily Av. Jan.-Nov. 1937	Total Jan.-Nov. 1938	Total Jan.-Nov. 1937	Total 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	447,989	474,236	149,628,516	158,394,883	172,822,797	148,707,864	134,912,143	122,913,903	122,601,191	106,289,292
Soviet Union	80,248	76,219	26,803,000	25,457,025	27,867,025‡	27,384,900	25,241,100	24,092,700	21,330,100	21,389,300
Venezuela	76,059	75,471	25,403,847	25,207,504	27,733,926	22,945,299	21,990,373	20,112,115	17,293,193	17,085,334
Iran	27,224	28,553	9,092,988	9,536,984	10,330,480	8,329,289	7,607,500	7,657,970	7,200,093	6,548,941
Netherland India: Sumatra	12,644	19,862	4,223,272	6,634,050	4,490,137	4,114,710	3,759,006	3,535,035	2,999,352	2,492,742
Borneo	4,694		1,567,872		1,739,607	1,773,545	1,815,998	1,924,234	2,013,849	2,043,707
Java	2,573		859,268		960,125	499,097	464,757	510,320	483,331	515,187
Ceram	227		75,876		72,139	50,446	41,862	36,738	38,300	41,605
Roumania	18,127	19,691	6,054,427	6,577,032	7,153,000	8,704,000	8,394,000	8,473,355	7,387,000	7,350,321
Mexico	13,496	18,710	4,507,984	6,249,461	6,896,657‡	6,090,842	5,973,955	5,666,857	5,049,109	4,870,175
Iraq	11,427	11,175	3,816,744	3,799,255	4,126,185‡	4,079,066	3,724,231	1,048,108	147,943	118,887
Colombia	8,200	7,754	2,739,121	2,589,902	2,844,251‡	2,614,092	2,452,635	2,416,432	1,833,606	2,287,835
Trinidad	6,776	5,962	2,263,349	1,991,706	2,181,676	1,862,796	1,642,446	1,533,122	1,345,532	1,495,009
Argentina	6,365	6,392	2,125,900	2,135,063	2,330,063	2,202,304	2,036,903	1,997,706	1,950,499	1,871,882
Peru	5,761	6,337	1,924,218	2,116,749	2,313,691	2,331,454	2,260,903	2,161,990	1,756,867	1,311,856
Bahrein	3,172	2,839	1,059,540	948,371	1,058,557	635,555	173,072	39,008	4,293	123
Burma	2,879	2,979	961,693	995,003	1,083,391	1,047,593	991,456	1,004,951	982,233	976,589
Brunei	1,914	1,567	639,363	523,435	576,545	470,991	471,842	386,478	290,808	171,432
Canada	2,603	978	869,524	326,816	378,430	190,495	182,820	178,233	144,686	131,937
Great Germany: Old Reich	1,522	1,218	508,298	413,474	453,451	444,600	427,400	317,500	238,600	229,700
Ostmark	180	90	60,440	30,160	33,010	7,473	6,616	4,172	860	120
Poland	1,382	1,372	461,678	458,301	501,301	510,630	514,760	529,200	550,670	556,680
Japan	993	940	331,691	314,051	354,040	341,976	326,580	266,520	212,667	239,367
Ecuador	875	842	292,541	280,949	306,326	275,293	245,434	231,947	229,578	226,423
British India	868	806	290,004	269,410	298,450	273,137	281,072	265,341	224,879	240,767
Saudi Arabia	142	21	48,093	7,725	8,070	2,447	Nil	Nil	Nil	Nil
Sarawak	555	598	185,582	199,815	217,085	221,126	253,799	277,513	315,259	332,819
Egypt	546	457	182,656	152,787	166,298	177,491	176,436	214,671	232,437	265,055
Albania	216	239	72,166	80,000	88,310	32,760	6,152	2,500	1,707	1,375
France	181	194	60,350	65,075	71,008	74,788	74,172	98,025	110,120	105,758
Hungary	111	37	44,513	12,360	13,910	13	Nil	Nil	Nil	Nil
Czechoslovakia	53	48	17,902	16,225	17,936	18,665	19,946	25,971	17,776	18,493
Bolivia	36	41	12,132	13,876	15,487	13,197	20,540	19,858	14,085	5,284
Italy	36	39	12,061	13,206	14,261	16,106	15,977	20,180	26,526	27,046
Other Countries	82	27	27,380	9,100	10,000	5,300	4,600	9,100	7,700	10,500
WORLD TOTAL	740,156	765,694	247,175,896	255,819,753	279,541,200	240,539,340	226,410,486	207,970,753	197,024,849	179,181,741

‡Preliminary Total

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing With Technical and Economic Aspects of the Petroleum Industry. Edited by Dr. O. W. Willcox

DRILLING

Heaving Shales, Their Characteristics, Economic Importance and Methods of Combating Them—First Paper—Michel T. Halbouty and Nicolas A. Kaldenbach, in OIL WEEKLY, Vol. 91 (1938), No. 7, pp. 17-20-22, 24-26.

The authors define a heaving shale as any shale which sloughs crumbles or otherwise falls into the hole in excessive quantities during normal drilling operations. Shales may owe their heaving character to their chemical or physical natures or to gas-cutting, but from the practical standpoint in any case the main cause of heaving is the creation of too large a pressure differential between the formation and the hole.

Aside from chemical treatment of the drilling mud (a subject which requires separate treatment) the combating of heaving shale requires attention to circumstances arising in drilling operations that may aggravate the trouble, such as insufficient removal of cuttings or heaving material, due to:

a. Poor mud-qualities, as low weight and low gel-strength. Sufficient weight and gel-strength are absolutely essential for successfully dealing with heaving shale, in keeping the pieces in suspension during circulation yet which change the mud into a plastic substance by gelling, the minute circulation is stopped.
b. Low upwards velocity of the mud between the drill-stem and the hole-wall, due either to insufficient pump-capacity or to cavities, which decrease the velocity below a critical minimum, with bridge-forming near the base of the cavity as a result.
c. Discontinuation of circulation. Apart from the fact that the mud, although in fairly good condition, may not prevent all settling out, as long as circulation is carried on, the rate of removal may equal or exceed the rate of heaving; but as soon as circulation is stopped, there is nothing left to balance the latter and circulation, after resumed, may not be adequate to make up for this loss of time or to re-establish the equilibrium.
d. Negligence, for instance: coming out of the hole before the mud is completely clean of cuttings or shale, or: making more cuttings than the mud-stream is able to carry off, in other words: drilling too fast. This leads to insufficient walling-off of the hole-wall as a result of too fast drilling, thus promoting water to seep into the formation and rapid breaking down of the shales. Other things may lead to aggravation of the heaving formation, such as fluctuations in mud-head opposite the formation apart from the question, whether the mud is underweighted; or discontinuation of circulation, as far as the change in physical condition of the hole is concerned.

Initial movement of heaving shale may be prevented by timely recognition of an approaching heaving shale body by means of correlation or otherwise, so that treatment of the mud, before penetration of the shale starts, can take place. Sloughing and caving, once started, tend to become progressively worse and eventually may grow completely beyond control.

Combating Heaving Shales; Second Paper—Michel T. Halbouty and Nicolas A. Kaldenbach, in OIL WEEKLY, vol. 91 (1938), No. 8, pp. 42, 44, 46, 48, 50, 52, 54.

The mechanical methods of combating heaving shales were outlined in the first paper. Much of the tendency of shales to heave depends on their property of absorbing water from the drilling mud and then to assume a colloidal form, in which condition they readily flow or slump into the hole. Shales containing bentonite are especially prone to become colloidal in this sense. Hence it has been natural to look for some substance or chemical which, when added to the mud will counteract the tendency of the shale to become hydrated.

Many substances have been tested from this point of view at least 76 formulæ have been proposed, but only a few have been found to be of any importance. The most effective chemical for reducing the viscosity of the mud is hexa-metaphosphate, which reduces gas-cutting of the mud. Silicate of soda mixed with a saturated brine is said to protect most shales from hydration, and when such a mixture contains 60 percent by volume of silicate any shale is said to be safe from disintegration. However, the object should be to get along as well as possible without the use of chemicals, and in each case the character of the native mud should be thoroughly studied.

Whatever chemical treatment is resorted to, arrangements must be made to maintain adequate and completely fool-proof circulation at all times so as to prevent any detritus from accumulating in the hole. If this is done, and if the character of the treated mud is such that a more or less impervious coating is formed on the walls, the shale will give a minimum of trouble.

Care and Maintenance of Instruments Used on Drilling Rigs—E. L. Decker and N. L. Dorn, before AMERICAN PETROLEUM INSTITUTE, Chicago meeting, November, 1938.

Today, the oil well driller can know, in pounds per square inch, what his circulation pressure is. He knows, in pounds, the total load on the derrick and the weight he is applying to the bit on bottom, thousands of feet away. He knows where the bottom is, and where the hole is going. Rotary-table speed, torque, mud density and viscosity, as well as other conditions, are subject to measurement. In short, wells today are drilled scientifically, with a half-dozen branches of knowledge available to help get the hole into productive sand. Engineers, metallurgists, geologists, and chemists share in the responsibility for the success or failure of well completions.

By far the greatest single element in this new scheme of things is the introduction and application to oilfield operations of accurate control and measuring instruments. With the growing use of these instruments, there has arisen the problem of maintaining and caring for them properly under the rough conditions imposed by oilfield work. One of the main difficulties seems to be that the average drill crew fails to grasp the essential difference between a tool and an instrument. Many rig crews think nothing of banging a survey outfit around as though it were a hammer or a wrench.

Instrument makers have built an unusual ruggedness into the various measuring devices used in the oilfields, but the fact remains that instruments inherently are delicate. They must be to have the necessary sensitivity.

From the reports submitted by operators one observes a decided variance in the methods of caring for instruments used on drilling rigs. From the writers' observance, it appears that those operators who have become instrument-conscious exert more or less effort towards a systematic routine of instrument care. However, there are literally hundreds of operators who, in the true sense of the word, have not become instrument-conscious, and therefore, make no effort whatever towards care of such equipment—except to provide repairs and replacements after breakdowns. Their lack of attention to this problem is probably due to the fact that, as compared to the total cost of a well, instrument maintenance is but a small item. On the other hand, if these operators would realize that the unseen cost of instrument failure is not a negligible item in the total cost of a well, they soon would establish some systematic maintenance routine.

OPERATION

Operating Costs of Multi-Cylinder Gas Engines—James McNeill, before AMERICAN PETROLEUM INSTITUTE, Chicago meeting, November, 1938.

At the present time approximately 2,500 multi-cylinder gas engines are used for pumping oil wells in California. In 1932 there were less than 50. This rapid increase is due both to the low first cost and operating economy of multi-cylinder gas engines and to the development of individually-powered portable pulling equipment which permits the use of lower-powered engines for pumping service.

Multi-cylinders as engines were first used in California during 1930. About this time small operators began to use old automobile engines on their wells. These engines proved to be surprisingly dependable and economical to operate, and in 1932 the industrial-engine manufacturers entered the field.

Engines of many types and sizes are now used. Sizes range from 100 to 800 cu. in. in displacement, with four, six, or eight cylinders. Loads as low as five horsepower and as high as 75 h.p. are being

carried economically—using, of course, the proper size engine for the job. Four-cylinder, 250- to 400-cu. in. engines predominate, but the present trend is toward six-cylinder engines because of their wider speed range and higher horsepower output per cubic inch of displacement.

This writer gives a summary of the operating costs of more than 250 multi-cylinder gas engines now doing pumping service for a California company, which has a trained maintenance personnel, and keeps accurate cost records. All of the engines are of the four-cycle type, and four different makes are represented. The costs shown are based upon lubricating oil at $0.68 per gal. repair and maintenance labor at $1.20 per hr., parts as billed, and fuel (dry gas) at $0.10 per 1,000 cu. ft. The engines have been grouped according to size and number of cylinders, and the operating costs are shown as averages per engine per day.

For the group of five horsepower engines the total operating cost, including fuel, is $0.40 per day per engine; from this the cost ranges up to $1.20 per day for the group with an average of 15 to 40 h.p.

Reviving Stripper Wells with Salt Water—F. R. Cozzens, in OIL WEEKLY, vol. 91 (1938), No. 1, p. 50.

The pores of the oil-sand face of old stripper wells may become clogged with wax and paraffin to such an extent that production of oil is greatly decreased. Experience in eastern oilfields has shown that such wells may be revived by a treatment with hot salt water. The technique is as follows:

About 100 bbl. of salt water is put into a tank, which can be heated on the bottom by means of a furnace; when the water has reached a temperature of about 200 deg. F. it is turned into the well through a two-inch pipe. When the salt water level reaches within 10 ft. of the top the pipe is removed from the tank and connected with an air compressor. Pressure is slowly applied until it registers 500 lb. in 24 hr. The well is then bailed as dry as possible and the process repeated once or twice, until upon removal of the water the well shows evidence of gas and live, frothy oil. The method has several variants, depending on the condition of the casing and whether an air compressor is available on the lease. Cost seldom exceeds $25 and the life of the well prolonged 20 to 40 percent.

TRANSPORTATION

Relation of Soil Properties to Corrosion of Buried Steel—Walter F. Rogers, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 30 (1938), No. 10, pp. 1181-1188.

It goes without saying that the subject of the corrosion of buried steel pipe is of great interest to the oil, gas and water industries. In this investigation made under the auspices of the Gulf Oil Corp., some new light is thrown on the matter. From laboratory and field studies it is shown that the controlling factor in soil corrosion of buried steel is the effect of variations in the soil water-air proportions. Laboratory variations of these factors allowed variations in corrosion rates of 31.1-1 to 56.5-1 to occur.

The electrical resistivity of a soil exerts an influence on its corrosion rate. Variations in this factor in the laboratory for Kalmia sand over the range 12,000 to 94 ohm-cm. resulted in a variation in corrosion rate between 1.5 and 1.

The pH of a soil exerts an influence on its corrosion rate. Laboratory tests show that varying the pH of Kalmia sand between 4.5 and 9.75 resulted in a variation in corrosion rate between 2.2 and 1.

Comparison of soil resistivity measurements at saturation with the corresponding pipe pit depth show that there is a definite trend between resistivity and corrosion. The trend is not sufficiently accurate, however, to be used as an index of soil corrosion. It can only be said that very few corrosive soils have resistivity values greater than 1800 ohm-cm. The majority of soils, however, possess values of resistivity less than this.

Comparison of soil pH values with field corrosion rates indicates a complete lack of any correlation between these quantities. The method cannot be used as a field index of soil corrosion.

The corrosion rate of a soil in the field may be determined by following its seasonal variation in water-air volumes and checking against a laboratory index test.

The most important conclusions which may be drawn from these tests deal with their practical value. It has been shown that the physical condition of a soil as regards its soil volume-water content controls its corrosion rate. By artificially or naturally controlling the soil volume-water content, any soil can be put in a condition which will allow corrosion to occur. In order to determine in the field whether or not a soil could be considered as corrosive, a seasonal study of its variation in moisture-air values would have to be made. Such a study would show definitely the corrosive action of the soil. Although this type of investigation is applicable to a study of a few soils, it cannot be made at present along an extensive right of way because of the mass of labor involved. The method cannot, therefore, be recommended for field use at present where a simple, inexpensive test is desired.

Certain conclusions can also be drawn regarding the value of these studies in protective pipe coatings. The data show that the physical condition of the soil controls the corrosion rate. Suppose that a permanent wrapping material without the use of any coating between the pipe and the wrapper were put around the pipe. This wrapper might allow free water to leak through the lap of the wrapper and to the pipe, but the effect of the soil physical property would be removed. The pipe would then suffer such corrosion as is experienced under slow conditions of wetting and drying. Although this may be fairly rapid under some conditions, in all probability the corrosion rate would be much less than if the pipe were exposed to the soil. If a coating were placed between the pipe and the wrapper, the corrosion rate would be further reduced. It is believed that the use of a permanent nonrotting wrapper for a pipe is the most important part of any protective coating system and can alone be relied upon to prevent the majority of the soil corrosion which would otherwise occur.

Use of Rust-Hole Records to Study Pipe Service—Walter F. Rogers, before AMERICAN PETROLEUM INSTITUTE, Chicago meeting, November, 1938.

From this study of the frequency of appearance of rust holes to a pipeline system over a period of 35 yr., a number of conclusions relative to the performance of pipelines have been drawn.

A mathematical relationship exists between the cumulative rust holes and their time of appearance. This relationship can be expressed by the formula.

$$R = bT^n$$

Where:

R = cumulative rust holes.
b = R when T is 1.
T = time, in years.
n = slope of the curve.

This type of curve for a pipeline will usually have more than one slope. Each slope is usually greater than 1, which expresses an increasing number of rust holes with time. The successive slopes, however, are of decreasing value—indicating a slowing-down or rust holes with time. This type of curve is of importance, as it enables extrapolation of the performance of the pipeline system for about two years. The ability to extrapolate the performance of a pipeline enables a forecast to be made of the money necessary for normal repairs, and a determination whether cathodic protection is justified economically.

The actual histories of lines laid bare and maintained through hot-spot reconditioning for 22 to 26 yr. show that a relatively small percentage of the total amount of pipe will be corroded during this period, and that the pipe can be maintained most economically through short-line reconditioning. Rust holes do not cease to appear through a pipeline with increasing age. This is due to the fact that the corrosive soils repeat in their regular cycle.

From the study of rust-hole-time curves for 467 mi. of six-inch pipe having an average age of 17 yr., and 555 mi. of eight-inch pipe having an average age of 15 yr., it has been determined that pipelines should be laid of the lightest wall commensurate with the pump pressure to be used. Such pipe selected on the basis of the pressure to be used should be known as pressure-weight rather than light- or heavy-weight pipe. This pipe, when laid, should be coated with a high-resistance coating. This coating will not prevent completely the future occurrence of all rust holes; but, when they start to develop, cathodic protection should be applied to the line. The total cost of pressure-weight pipe plus coating, plus cathodic protection up to 12 in. for 700-lb. working pressure, is sufficiently less than the cost of heavy-weight pipe completely to justify its use.

Value of Soil Survey Methods—J. M. Pearson, before AMERICAN PETROLEUM INSTITUTE, Chicago meeting, November, 1938.

Soil-survey methods are valuable to pipeline technologists because their use may lead to a reduction of long-time over-all operating costs; a reduction of the rate of physical depreciation, and an increase in salvage value of buried lines; and a reduction of hazards entailing large liabilities.

The technologist should bear in mind the ultimate use to which the survey will be put, and the principles of corrosion in its many forms in different soils. He should then map the soils traversed according to type as determined by: texture (coarse, fine, colloidal, etc.); aeration (wet or dry, access to air, etc.); water (pH, average moisture content, variability, etc.); total acidity; dissolved salts (especially Cl, SO_4, NO_3, CO_3); resistivity.

These values of measured quantities can probably best be the averages of well-distributed tests in each soil type.

He must obtain numerical data from other pipelines in these or similar soils on their corrosion experience. From this, and soil samples, he can determine soil constants from experience of other lines; correlate soil constants with soil test data (from this a usable correlation of some soil property with experienced corrosion might be found.); subject any proposed criterion of soil corrosiveness to cut-and-try tests to correlate the predictions of the method with experience. He must also establish criteria that may be used in the field to locate coatings with the best probability of success.

There is little doubt that, as time goes on, better means of soil mapping will be available. At present there are few corrosion technologists who feel confident of recognizing many of the soil types of even the U. S. Bureau of Standards tests.

In the meantime careful measurements of the effects of corrosion on old lines and rational analysis of the data in correlation with soil properties will improve our understanding of the phenomena, and will furnish useful tools in combating corrosion.

REFINING

Control of Wax-Distillate Quality—E. A. Burch, J. W. Donnell, L. L. Davis and Anton Nelsen, before AMERICAN PETROLEUM INSTITUTE, Chicago meeting, November, 1938.

The laboratory and pilot-plant methods of controlling the quality of wax distillates developed and used by Continental Oil Company and a survey of five Oklahoma wax distillates by the chemical engineering department of the University of Oklahoma are given in four sections:

The analytical separation of wax-oil mixtures and methods for the selection of the correct solvents and for the determination of the theoretical yield of wax of any desired melting point from a given slack wax are discussed.

A pilot sweating plant is described, and the various factors affecting the yields of scale wax from the sweating operation are outlined.

A modified vacuum-distillation apparatus is described, and the relationship between viscosity and mid-distilling temperature is recommended as a basis for the estimation of pale oil yields.

Conclusions from the work are summarized as follows: Although the distillation range of a wax distillate is a valuable measure of the quality and uniformity of a wax distillate from a given source, it is not an inherent characteristic; and does not necessarily rate distillates from different sources in order of merit.

The pale-oil yield from a wax distillate depends upon the distillation range, viscosity-temperature characteristics, and wax content of the distillate.

The pressability of a wax distillate is determined by its viscosity, wax content, and the crystal structure or character of the wax. For oil from any given source, these factors are controlled by the distillation range and quality of fractionation.

The physical condition of the press, such as cleanliness of blankets, materially affects pressing efficiency.

The yield of scale wax from sweating depends principally upon the oil content of the slack wax, the oil content of the slack wax being dependent on the efficiency of pressing.

Other factors affecting sweat-plant operation are chilling temperatures, amount of re-cycle, melting point, and oil content of finished scale wax, and the actual quality of the wax crystals.

CHEMISTRY

Dehydropolymerization of Ethylene—V. I. Komarewsky and N. Balai in INDUSTRIAL ENGINEERING CHEMISTRY, vol. 30, (1938), No. 9, pp. 1051-1053.

By subjecting ethylene to catalytic polymerization in the presence of a polymerizing (phosphoric acid) and dehydrogenating catalyst, a directed conjunct polymerization takes place with increased formation of aromatic hydrocarbons. By subjecting ethylene to a thermal polymerization (no polymerization catalyst) in the presence of a dehydrogenating catalyst (nickel), aromatic hydrocarbons are formed. Both reactions might be called dehydropolymerization.

These facts prove the correctness of the mechanism of ethylene polymerization suggested by Ipatieff and Pines.

Composition of Waste Paraffin—E. Podgorski and S. von Pilat, in PETROLEUM, Vol. 34 (1938), No. 42, pp. 1-3.

The refining of paraffin recovered from bleaching earths such as Floridin, Tonsil, etc., often presents serious practical difficulties, and is a problem which does not seem to have received much study.

In their investigation of the subject the authors extracted the spent earth with gasoline, followed by extraction with hot dilute caustic soda under pressure. This extract was then extracted with aqueous alcohol. This operation separated the fatty acids and sulphonic acid salts, and paraffin was isolated from the alcoholic extract by means of boiling acetone. The acetone insoluble residue was then extracted with alcohol and treated with acid in a series of operations (flow-sheet given) by which considerable quantities of hydroxy fatty acids and sulphonic acids were obtained. These sulphonic acids correspond to the formula $C_{31}H_{58}SO_3H$. and are evidently derived from a bicyclic naphthene hydrocarbon of the formula $C_{31}H_{58}$.

These studies seem to indicate that hot acetone extraction is the best method of separating the absorbed paraffin from contaminating substances. After purification by the indicated process and treatment with vegetable carbon the recovered paraffin is a good commercial product. No details of costs are given.

A Study of Changes that Occur in Lubricating Oils in Internal Combustion Engines—H. Weiss and A. Maillard, in JOURNAL INSTITUTE PETROLEUM TECHNOLOGISTS, vol./24 (1938), No. 178, pp. 407-420.

In this study the authors offer not just one more test on the aging of motor oils, but a means of clarifying an aspect of this complicated question. They have studied various changes of oils in Diesel and in sparking ignition engines, with particular reference to the formation of products insoluble in chloroform which are also insoluble in hot oil and may be a source of danger.

The phenomena in question are illustrated by the case of an engine piston which had gone 60,000 km. without overhaul, and was black half-way up. The deposit was removed in bands parallel to the piston head and examined. The bottom band was completely soluble in chloroform, and that at the top practically insoluble. If this insoluble substance had been soot it would have been found also on the lower bands.

This would seem to identify hard carbonaceous matters insoluble in chloroform. These insoluble oxidation products are formed in the cylinder from the oil and not from the fuel. Hence this character is worth looking for in methods based on artificial aging.

Hydrocarbons in the Lubricant Fraction of Petroleum—Frederick D. Rossini, before AMERICAN PETROLEUM INSTITUTE, Chicago Meeting November, 1938.

The results are summarized of an experimental study, covering a period of five years, of the chemical constitution of the lubricant fraction of a Mid-Continent petroleum, which has been carried on as one of the problems of the American Petroleum Institute Research Project Six at the National Bureau of Standards. A complete analysis with respect to size and type of molecules has been made of both the water-white oil and extract portions, which together constitute about 57 percent of the entire lubricant fraction. The kinds of molecules in the wax portions, which constitutes about 35 percent of the lubricant fraction, are known in a general way, but much less definitely than those in the water-white oil and extract portions. The kinds of molecules in the asphaltic portion, which constitutes about eight percent of the lubricant fraction, are surmised. The significance and interpretation of the data are discussed. It is pointed out that, in terms of significant amounts, every hydrocarbon in the water-white oil and extract portions contains one or more naphthene rings, which is to say that there are no purely paraffinic or aromatic hydrocarbons in these portions.

Taking the lubricant fraction as 100 percent, the following approximate average analysis with respect to the kinds of molecules in this Mid-Continent petroleum is reported:

About 43 to 51 percent is composed of molecules with 1, 2, or 3 naphthene rings, together with the appropriate paraffin side chains.

About 8.3 percent is composed of molecules with 1, 2, or 3 naphthene rings and 1 aromatic ring, together with the appropriate paraffin side chains.

About 8.1 percent is composed of molecules with 2 naphthene rings and 2 aromatic rings (condensed) together with the appropriate paraffin side chains.

About 6.6 percent is composed of molecules with 1 naphthene ring and 3 aromatic ring (condensed) together with the appropriate paraffin side chains.

About 18 to 26 percent is composed of normal (straight-chain) paraffins, plus possibly some iso-paraffins (branched-chain).

About 8 percent is composed of the asphaltic constituents, which have not been investigated.

As to the technological and scientific applications that may eventually be made of the information supplied by a research of this character, the following points are offered for consideration.

The knowledge obtained will aid and give impetus to the industry's problem of producing, from the lubricant fraction of petroleum, materials of special properties which better can fill the modern requirements arising from the need for greater efficiency, higher speeds, and more concentrated power, and the use of high pressures and high and low temperatures.

The results obtained will aid in the problem of producing lubricating and other oils synthetically, because the knowledge of what kinds of molecules are in lubricating oil from petroleum can help decide what molecules should be synthesized, and because the knowledge of the method and extent of separation, and of the properties, will be useful in producing homogeneous synthetic materials and in identifying the constituents.

Discovery and Synthesis of New Highest Molecular Paraffins—Helmut Pichler, in PETROLEUM, vol. 34 (1938), No. 38, pp. 1-5.

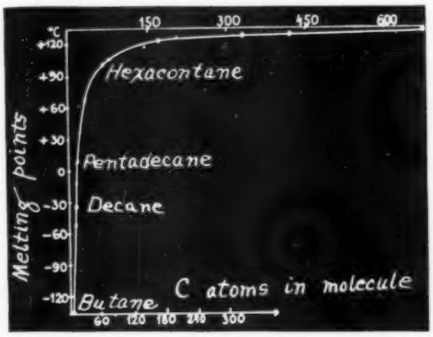
Up to a short time ago the opinion has prevailed that the paraffins formed in the Fischer-Tropsch gasoline synthesis under atmospheric pressure could have a maximum molecular weight not exceeding 2,000 corresponding to a maximum melting point of 117 to 118 deg. C., and that any further increase of molecular weight would scarcely bring any noteworthy elevation of melting point.

The Fischer-Tropsch synthesis has been based on the use of cobalt, nickel or iron as catalysts in the hydrogenation of carbon monoxide at atmospheric pressure; these catalysts give rise to a desirable proportion of liquid paraffins and a minimum of solid paraffins. It is now found that a ruthenium catalyst produces a much larger proportion of the solid waxes, and that these have higher molecular weights than any paraffins heretofore known, especially when produced at higher pressures.

The optimum temperature in these experiments was around 200 deg. C., the optimum pressure 100 atmos., the rate of operation one liter of mixed gas (one part CO_2, two parts H) per gram of catalyst. Under these conditions the apparatus was kept in operation for 26 weeks without any shutdown for regeneration, and without any falling off of the yield of liquid and solid hydrocarbons, amounting to 142 grams of synthetic products per cubic meter of mixed gas, besides five to 10 gr. of gas/oil hydrocarbons (close to the theoretical yield). The reaction

products contained about 100 gr. of oil-free solid paraffins which were snow white even in the raw condition. By treating the raw product with solvents various heretofore unknown paraffins were obtained having melting points up to 132 deg. C., and molecular weights of 7,000 to 9,000.

These results give new material for deducing the relation between the melting points of paraffins and the number of carbon atoms in the molecule (see diagram).



Rhodium as a catalyst has a similar action, but produces more liquid and gaseous products; platinum, iridium and palladium are much less suitable.

Dehydrogenation of the Lower Paraffins by Alumina Catalysts—J. Burgin, H. Groll and R. M. Roberts, in REFINER, Vol. 17 (1938), No. 10, pp. 495, 499.

The low molecular weight paraffins and olefins formerly produced as undesirable by-products of the cracking operation have now been turned to good account in the manufacture of synthetic chemicals and high octane gasoline, and an actual shortage in the usual supply of these hydrocarbons seems to impend. Petroleum chemists are therefore looking for new ways of increasing this supply.

In the present study the authors have investigated the conversion of propane, normal butane and isobutane to the corresponding olefins by passing them in vapor form over an activated alumina catalyst, alone and combined with chromium oxide. A suitable activated alumina that has good dehydrogenizing properties is prepared in the laboratory by decomposing sodium aluminate by means of carbon dioxide and drying the washed precipitate at 600 deg. C. The alumina thus prepared may be impregnated with an alkali salt of chromic acid. These catalysts have been regenerated (by burning off deposited carbon) over 200 times with little loss of activity. The percentage of conversion of the paraffins to olefins per pass varies from around 20 to around 35 percent, and is a function of space-velocity at 550 deg. to 650 deg. A small amount of water is essential to the dehydrogenation process.

Polymerization of Ethylene With Compounds of Aluminum as Catalyst—H. C. Hall and A. W. Nash, in JOURNAL INSTITUTION PETROLEUM TECHNOLOGISTS, Vol. 24 (1938), No. 179, pp. 471-495.

The catalytic polymerization reactions of ethylene are reviewed with particular reference to that induced by aluminum chloride. The effect of metallic aluminum on this latter reaction has been investigated at varying temperatures and is described in detail. The products of reaction include organo-metallic ethyl derivatives of aluminum and polymerized hydrocarbon oils of high boiling point. The residual and distillate lubricating-oil fractions therefrom have relatively high viscosity indices in contrast to those from the polymerization of ethylene with aluminum chloride alone, the optimum values being obtained for oils from the reaction at 200 deg.

It is shown that the cracking action of aluminum chloride on hydrocarbon oils may be completely inhibited by the presence of metallic aluminum or magnesium, zinc having a less pronounced effect.

At temperatures above 200 deg. C. the polymerization reaction is further complicated by the catalytic activity of the aluminum ethyl derivatives. Under suitable conditions high yields of butene-L, hexenes and octenes can be obtained by direct polymerization of ethylene, using either aluminum diethyl chloride or the simple aluminum chloride-aluminum catalyst. The reaction is shown to be in accordance with the mechanism proposed by Taylor and Jones for the polymerization of ethylene by free alkyl radicals.

Aromatization of Paraffin by Action of Aluminum Chloride—C. Otin and M. Dina, in MONITEUR PETROLE ROUMAIN, Vol. 39 (1938), No. 20, pp. 1613-1619.

A hard paraffin (melting point 53.9 deg. C., molecular weight 354.7) was heated to 210 deg. C. in the presence of activated aluminum while a current of dry hydrochloric acid gas was passed through the mass. Aluminum chloride in *statu nascendi* was thus formed and acted on the paraffin to produce 80 percent of gasoline and a solid residue which was decomposable by water with formation of unsaturated heavy oils. The distillate contained 17.2 percent of aromatic hydrocarbons.

The reaction is explained on the assumption that the paraffin is split (cracked) giving rise to completely saturated (or aromatic) hydrocarbons and unsaturated heavy hydrocarbons. The yield of liquid products is larger than is obtainable from previously prepared anhydrous aluminum chloride; this is due in part to the fact that the aluminum chloride here formed acts while in the nascent condition, and in part to nascent hydrogen which is formed at the same time as the chloride. Unlike nascent aluminum chloride, ordinary anhydrous aluminum chloride does not favor the formation of aromatic hydrocarbons under these circumstances. The fact that aromatics are formed by nascent aluminum chloride indicates a complex process of splitting, reduction, polymerization, isomerization and cyclization.

Motor Fuel of High Octane Number; Synthesis of Isooctane from Water Gas—G. Natta and M. Baccaredda, in RIVISTA ITALIANA DEL PETROLI, Vol. 6 (1938), No. 65, pp. 14-19.

Isobutylene was obtained by dehydrating isobutyl-alcohol (which was itself obtained in good yield as a by-product from the synthesis of methanol from water gas), and was dimerized with high yields of isooctene by a new process at ordinary temperatures through the use of a gaseous catalyst in the presence of a solid catalyst. The isobutylene is mixed with a small quantity of hydrochloric acid; the dry mixture is warmed to a temperature between 100 deg. and 250 deg. C. and passed over solid alumina previously activated by heating to 400 deg. to 450 deg. C. It is supposed that the first step in the reaction is the formation of isobutyl chloride which immediately reacts with a molecule of free isobutylene to form a molecule of isooctene, with regeneration of a molecule of hydrochloric acid. (It was verified by experiment that this synthesis proceeds much more slowly with straight chain olefines than with iso-olefines).

The solid catalyst is regenerated when necessary by heating in the air at 400 deg. to 450 deg. C.

The yield of total polymers increases asymptotically with the percentage of hydrochloric acid gas in the mixture; the most favorable temperature is 190 deg. C. The percentage of higher polymers is the greater the lower the temperature, but by proper management may be kept below 20 percent; with 10 percent HCl in the gas the yield per pass may reach 55 percent. Unchanged isobutylene is returned to the cycle. Experiment showed that isobutyl chloride is not as good a catalyst as HCl. However, recycling a mixture of isobutylene, HCl and isobutyl chloride appears to be advantageous.

The isooctene is easily hydrogenized to isooctane. There is thus opened up the possibility of obtaining isooctane through the alkaline catalyzation of water gas, with production of isobutyl alcohol in good yields.

PHYSICS

Study of Oil Refining by Means of a Photographic Method—J. J. Trillat and A. Aubry, COMPTES RENDUS ACAD. SCIENCES, Aug. 22, 1938 (REV. PETROLIFERE 1938, p. 1205).

The object of oil refining is to remove impurities which are characterized by large surface activity, and which act to increase the tension at the interface between water and oil. The authors illustrate the fact by means of a partly refined vaseline oil. They obtain a photographic record of the curve of surface tension for different states of purity of the oil, and recommend the method as a control of the refining process.

Significance of the Critical Phenomena in Oil and Gas Production—D. L. Katz and C. G. Singleterry in PETROLEUM TECHNOLOGY, August, 1938, T. P. No. 971 of the American Inst. of M. and M. Engineers; 17 pages.

This paper reports experimental data on a mixture of natural gasolines and natural gas that was subjected to a critical pressure; also on a mixture of crude oil and natural gas at pressures up to 9,000 lb. per sq. in.

Although the range of these experiments does not include all gas and all oil mixtures, the data obtained show that hydrocarbon vapors may give gas-liquid ratios of 5,000 to 10,000 cu. ft. per bbl. of liquid and that ratios for saturated liquids are unlikely to pass 5,000 cu. ft. per bbl. of residual liquid for any natural fluid. Critical temperatures of mixtures are defined and shown to have little significance if the pressure is appreciably below the critical pressure. Retrograde condensation may occur upon isothermal expansion of vapors coming from a two-phase system below its critical temperature, because the vapors must be considered in terms of the phase diagram after removal from the two-phase system and hence be above the critical temperature.

The gradual changes that occur upon compression of the gaseous and liquid phases before critical conditions are reached should be of interest to production groups because the data presented point to critical pressures above 10,000 lb. for mixtures void of excess intermediate constituents between methane and the high-boiling compounds. For more volatile mixtures, critical pressures may occur in the range of reservoir pressures found in deep wells. The increased concentration of gaseous constituents in the liquid phase may be expected to eliminate the tar constituents of the liquid produced.

Viscosity of Petroleum Emulsions—Louis I. Munson, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 30 (1938), No. 11, pp. 1287-1291.

Emulsions consisting of crude petroleum and water are daily produced in hundreds of thousands of barrels in the United States and abroad, but little information is available in the literature regarding this type of emulsion, especially as regards

viscosity. Emulsified oil is lifted to the surface with greater difficulty and at greater expense than clean oil. It is handled and transported under the same relatively unfavorable conditions, although the pipeline specifications limiting impurities to low percentages (almost always three percent or less) bar emulsions of high water content from these common carriers.

Emulsions of water in oil vary in viscosity, depending on the nature of the oil, the proportion of water emulsified, the fineness of dispersion, the temperature, and possibly other factors. The present investigation was undertaken in connection with the deëmulsification of such wet oils, because high viscosity is a retarding factor in the separation of the phases in this process. In addition, there are instances where highly viscous crudes are required to be handled by special procedures in the deëmulsification process because of their viscosity. There are also instances where the applicability of special apparatus, such as excelsior or hay tanks, is determined by the viscosity of the liquids to be passed through them.

The author's experimental results in general show that the maximum viscosity ratio (emulsion viscosity relative to clean oil viscosity at the same temperature) to be expected in emulsions of any of the crude oils tested is approximately 1.3 for those containing 10 percent water, 1.8 for those containing 20 percent water, 2.7 for those containing 30 percent water, and 4.1 for those containing 40 percent water.

This work will be continued with emulsions from other areas to determine how general are the conclusions proposed here. The applicability of the method to emulsions which sludge (stratify into concentrated emulsion and relatively clean oil) has not been investigated but appears doubtful unless large disperse-phase volumes are employed. The values for viscosity ratio to be expected with higher proportions of water are also to be determined on the present oil samples, using a colloid mill to produce the emulsions. Hand emulsification is believed to have reached substantially the limit of applicability in the present tests. Since emulsions containing greater percentages of water will be more viscous, no attempt has been made to produce them by the present method.

Calculation of the Octane Number of Gasoline from Physical Data—V. Schneider and G. W. Stanton, in REFINER, Vol. 17 (1938) No. 10, pp. 509, 315.

An accurate, simple method for calculating the octane number of gasoline from such physical data as gravity, distillation data, and percent unsaturates i· needed by small refiners who ordinarily must send samples of their gasoline, periodically to large refiners who have equipment to run octane number. This service is usually costly and time taking, thus limiting the small refiner to infrequent checking of the anti-knock of his gasoline.

A calculation of this nature has until recently been hindered due to the lack of sufficient data on the octane number of pure hydrocarbons and a short, accurate method for analyzing gasoline. Recently a large quantity of data has been published giving the anti-knock rating of all types of hydrocarbons. Also a better method for analyzing gasoline for its percent aromatics, naphthenes, aliphatics, and unsaturates has been developed. It can be seen that if the composition of a gasoline is known, the percent of each component in the gasoline could be multiplied by its blending value in octane number and the sum would be the octane number of the gasoline. In general this was the starting basis of the calculations given here.

The method requires a knowledge of the approximate composition of each 10 percent cut of gasoline as regards the average distribution of aliphatics, naphthenes, aromatics and unsaturates. This information can be obtained by analytical methods now available and the octane number of each cut can be related by curves (which the authors give) to boiling point in degrees F. and specific gravity. A correction can be applied for percent of unsaturates. This method is especially adapted to the needs of manufacturers of low grade gasolines and the results with few exceptions are accurate within three percent.

Partial Volumetric Behavior of the Lighter Hydrocarbons in the Liquid Phase—B. H. Sage, B. L. Hicks and W. N. Lacey, before AMERICAN PETROLEUM INSTITUTE, Chicago meeting, November, 1938.

The prediction of the specific volume of homogeneous and heterogeneous complex hydrocarbon mixtures is of importance to the petroleum technologist. The partial specific volumes of each of the components in both the liquid and gas phases are of value in making such predictions. The partial volumes of the paraffin hydrocarbons from methane through pentane in the liquid phases of the various hydrocarbon systems that have been studied experimentally are presented in tabular form, together with similar information for two complex liquids. A tentative correlation of these partial volumes has been prepared to permit the prediction of the specific volume of naturally-occurring hydrocarbon liquids in the ranges of pressure and temperature that commonly are encountered in production practice. This correlation represents a preliminary attack upon one part of the major problem of the prediction of the volumes of hydrocarbon mixtures under widely-varying conditions.

Solubility Relations and Volumetric Behavior of Three Gravities of Crudes and Associated Gases—J. E. Gosline and C. R. Dodson, before AMERICAN PETROLEUM INSTITUTE, Chicago meeting, November, 1938.

A knowledge of the physical properties of reservoir fluids is fundamental to a rational treatment of many problems in production engineering. Unfortunately, the behavior of naturally-occurring hydrocarbon systems is extremely complex and, up to the present time, not generally predictable from a knowledge of the composition of the system. Some companies, therefore, have determined experimentally the necessary constants for representative samples of the fluids under question. Such determinations usually are restricted in application to conditions simulating closely those under which the samples were procured, inasmuch as relatively small variations in composition of material exert an appreciable influence upon certain of the characteristics of the system. In some cases such as, for example, a one-zone reservoir containing under-saturated crude of uniform gravity, a single set of determinations upon representative samples will be applicable to the whole field. Usually, however, where variations in formation gas-oil ratio and gravity occur, determinations upon a series of samples are necessary. Ordinarily, if properly sampled, the results of such determinations reasonably are correlative with gravity of residual crude—thus permitting a close approximation of factors for intermediate conditions.

In this paper are presented the results obtained from three mixtures from flowing wells producing from a sand of upper Miocene age in the San Joaquin Valley, California. Of the many possible correlations on an oil-gravity basis, a sufficient number are presented to indicate the trend of certain of the most commonly-used factors. The measurements were made for a series of pressures, temperatures, and gas-oil ratios. To illustrate the nature of influence of residual crude gravity upon certain of the more-commonly used engineering factors, several correlations are indicated. Values of formation volume are tabulated, and factors for converting formation volume to specific volume are included.

Hydrogenation of Coal and Tar Oils in Turbulent Flow—G. Morgan and J. I. Veryard, in JOURNAL SOCIETY CHEMICAL INDUSTRY, Vol. 57 (1938), p. 152T.

It was found that a low-temperature tar oil could be hydrogenated with a good yield of light oil and gas without the use of catalysts, provided that the tar was vigorously agitated during the operation. It was also found that when suspended or dispersed in a heavy oil, a finely ground coal could be transformed in a short reaction time into oil with a nearly 100 percent yield without catalysts; under the same conditions tar acids are converted into neutral oils.

Gasification of Italian Fuels with Oxygen—G. Natta and R. Rigamonti, in RIVISTA ITALIANA DEL PETROLIO, vol. 6 (1938), No. 65, pp. 20-23.

Water gas, made by passing steam over hot coke, has become the standard raw material for the systhesis of petroleum by such processes as the Fischer-Tropsch. From an autarchial standpoint, especially in a country with small resources of coal (and that of poor quality) the common method of producing water gas is wasteful; and besides, the water gas is contaminated with more or less of nitrogen and methane which are objectionable not only because they are inert, but also because they make it more difficult to operate the oil synthesis under pressure.

These impurities may be greatly reduced by employing oxygen instead of air for gasifying the solid fuel. This appears to be practicable by obtaining oxygen by liquefying air at the source of the raw material; only 0.13 to 0.18 cubic meter of oxygen is required for the production of one meter of water gas, which for Italian conditions is well within reason. The authors have worked out the idea to an extent that allows the production of water gas from the lowest grade of Italian coals and semi-coking lignites.

The water gas so obtained is well suited to the production of organic materials, including isobutyl alcohol, which can readily be transformed into isooctane that is extremely valuable as aviation fuel.

Preparation of Brown Coal Extract and its Use as Solid Motor Fuel—Fritz Jostes and Konrad Siebert, in OEL UND KOHLE, Vol. 14, (1938), No. 38, pp. 777-783, No. 39, pp. 799-802.

In the manufacture of artificial petroleum by the hydrogenation of coal one of the principal problems has been to get rid of the ash which all coal contains and which creates difficulties in the operation of the hydrogenation process where the finely ground coal is suspended in a neutral cycle oil. This difficulty has been removed, at least in principle, by the Potte-Broche process, in which the coal is dissolved in a mixture of phenol and tetralin. The insoluble ash is filtered off and the extract hydrogenated.

In approaching this subject the present authors reason that if an ash-free coal extract can be obtained by treating the coal with solvents, this same extract might serve for direct use as a solid fuel for internal combustion engines. They recall that the original purpose of the inventor of the Diesel engine was to produce a machine that would obtain the energy of coal directly and thus avoid the roundabout and wasteful process of using the coal to produce steam. This original idea turned out to be perfectly sound in principle, but its practical mate-

riafization failed on account of the presence of mineral substances in the coal, which created serious difficulties, not the least of which was the rapid wear of the engine parts.

In their experiments the authors used a solvent consisting of technical cresols with an addition up to 30 percent of tetralin. They found that brown coal (lignite) contains two groups of extractable substances which differ in the time required to dissolve them. The easily soluble bitumens, amounting to about 80 percent of the weight of the coal, are dissolved in about an hour at 350 deg. C. The remainder of the soluble substances, amounting to about 10 percent, require an extraction period of six to seven hours.

When the solvent is distilled off the extract is obtained as a loose powder tht can be ground to any desired degree of fineness, and can be handled and conveyed without formation of lumps. Its properties qualify it for use in the most recent German engines designed to operate on solid fuel. It is easily ignited and although not entirely ash-free (78 gr. of ash per 10,000 kg. calories) the ash is of a harmless nature.

As regards the economics of the solid fuel produced in this way, no direct experience has yet been acquired, but it is reasoned that since the Potte-Broche process of making extracts of coal is within the range of economic possibility under German conditions, the reduction of such extracts to the solid form for direct use should also have fair prospects.

USE

Investigations of Vapor Lock in Aviation Fuel Systems (C. F. R. Progress Report)—O. C. Bridgeman, before SOCIETY AUTOMOTIVE ENGINEERS, Los Angeles meeting, 1938.

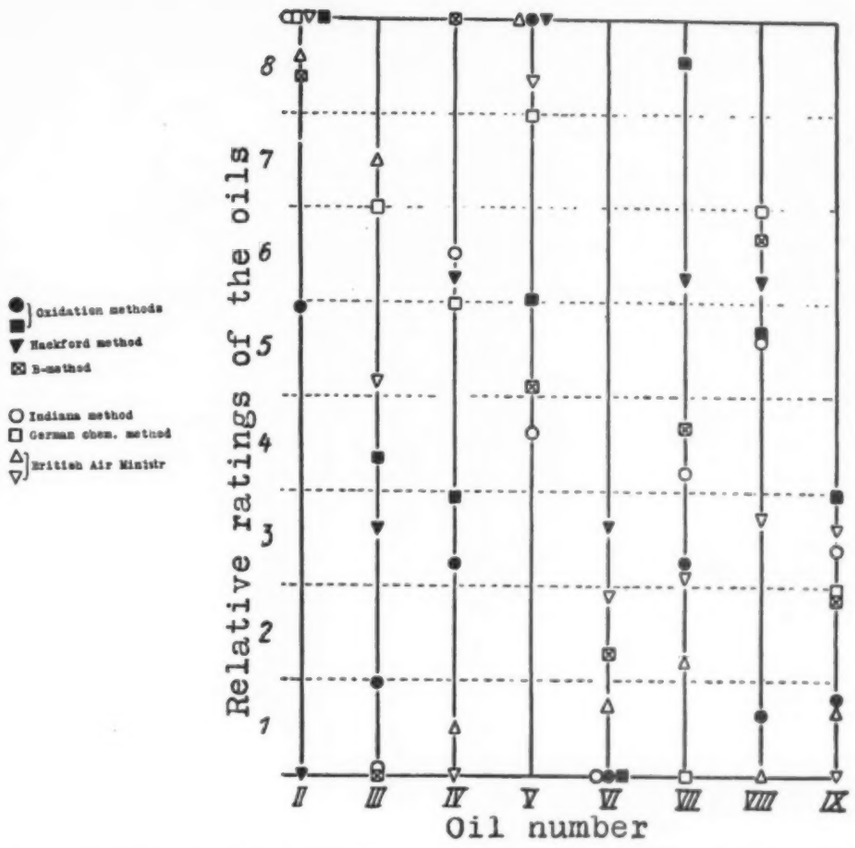
The results of this investigation are presented in Air Corps Technical Report 4404 (July 27th, 1938) and point the way towards the solution of the various problems which have been connected with fuel pumps particularly at high altitude operation.

It was concluded that vapor lock occurs at the outlet of the relief valve at high altitudes due to the fact that the excess fuel is released from a comparatively high pressure to a low pressure near or below the boiling point of the fuel. The vapor so formed is recirculated around to the inlet of the fuel pump and impedes or even prevents the entering of liquid fuel into the pump. Elimination of the return line to the inlet side of the pump and the adoption of a system in which the fuel is by-passed back to the tank is satisfactory from theoretical grounds, but is impractical due to the increase in complexity of the fuel system installation.

One of the most interesting results obtained was the definite evidence that the speed of the conventional type of fuel pump must be held below 1,500 r.p.m. in order that that pumping capacity will not decrease under high altitude conditions. At speeds above 1,500 r.p.m. cavitation effects are observed.

It was also concluded that the plumbing between the supply tanks and the fuel pump must be sufficiently large and that the fuel pump must be mounted sufficiently lower than the level of the gasoline in the tanks so that the fuel will flow by gravity to the pump at a greater rate than is required by the engine. In this case, the hydrostatic h ad at the pump inlet will be great enough so that vaporization of the fuel at the pump inlet due to hydraulic losses will be less than the vaporization of fuel in the tank.

Flight tests incorporating the results of the laboratory investigation have indicated that it is possible to reach altitudes considerably higher than those normally reached at present without vapor lock and without the use of fuel coolers.



Characteristics Relative to Ring Sticking and Engine Cleanliness of Mid-Continent Lubricating Oils—J. V. Brazier and Sidney Born, before SOCIETY AUTOMOTIVE ENGINEERS, Tulsa meeting, 1938.

The writers conducted a series of engine dynamometer tests to compare the relative lubricating values of two Mid-Continent oils with those of two eastern oils made by similar processing methods. Elevated crank case temperatures were maintained to accelerate oil break-down. After a 50-hr. run the records were appraised from the standpoint of oil consumption, engine deposits and viscosity increase of the used oil.

Consumption figures were fairly close. The carbon formed by the Mid-Continent oils was soft and flaky, that from the Pennsylvania oils was dense and tenacious. The Mid-Continent used oils contained more oxidized products than the Pennsylvania oils, although not necessarily as solids precipitated in the crank case. On the other hand the Pennsylvania oils showed a greater increase in viscosity due to polymerization "which in the eyes of competent authorities is a far more serious problem."

In comparing oils made from crudes of different origin, the writers believe that oils made in the conventional manner are more likely to retain the natural stability characteristics of the crude than are the solvent extracted oils. Therefore, the Mid-Continent and Pennsylvania oils referred to in this paper are not solvent extracted products.

Due to economic reasons and the adaptability of solvent refining to any grade of lubricating distillate or residual stock, considerable quantities of lubricating oils are made from all types of crude by this method. However, it is reasonable to assume that the quality of paraffin oils made by selective solvent methods is more dependent on the method of solvent refining than on the crude used.

Value of Laboratory Methods for Determining the Aging Propensities of Mineral Oils—M. Marder and V. Tolkmitt, in OEL UND KOHLE, vol. 14 (1938), No. 30, pp. 615-619; No. 31, pp. 635-637.

Hardly any problem relating to mineral oils, especially lubricating and cylinder oils, has attracted more interest than the question of the deterioration of these oils in use. Evidence of this interest exists in the large number of discussions on the subject and in the number of methods that have been devised for measuring aging tendencies.

Recently Noack has made a comparative study of six of these methods as applied to nine different oils. The authors analyze Noack's data, and reproduce the results in the accompanying diagram, which shows how the different methods rate the same oil.

The six methods compared were: Indiana method (mg. asphalt per 10 gr. of oil); German chemical method (tar number, percent); British Air Ministry methods (viscosity increase percent coke test); Oxidation methods (aging number, acid number); Hackford method (neutralization number); B-Method (mg. asphalt per 10 gr. of oil). The B-method is one used by a German industrial concern.

When the aging qualities of these oils as disclosed by these methods of testing are compared, it is seen that the same oil is given different ratings by different methods. Individual oils are given somewhat comparable ratings by all methods (for example Nos. VI and IX) whereas there are complete discrepancies as to other oils (compare oils Nos. III and IV).

These results leave the important matter of determining the aging quality of an oil up in the air, so to speak. A little reflection will show that this can hardly be otherwise because the conditions under which an oil is used, especially a motor oil,

are infinitely varied as regards the factors time, temperature and pressure, which may subject the oil to an infinite variety of condensations, polymerizations and cracking reactions. Such a complex is difficult to reproduce in a laboratory apparatus which functions under fixed conditions according to a fixed method.

Still, the aging of an oil is too important a matter to disregard without further attempts to find a solution. The authors indicate two possibilities. One is to age the oil artificially under the most severe conditions to which a motor oil is likely to be subjected. This will establish a limit of reference, which will be based on extreme or exceptional rather than on normal conditions; an oil that passes such an extreme test would qualify as a good aviation oil.

The second possibility is to establish the aging characteristics under normal conditions by test block and road tests, and compare results with those obtained under laboratory conditions. A new method worked out by the German Army Ordnance Department is based on a 50 hr. engine test on the block, compared with a one-hour test in the modified Noack apparatus at 200 deg. C. and 20 mm. reduced pressure. The results show excellent concordance.

The modified Noack apparatus consists of an electrically heated aluminum block in which is placed a brass crucible containing 65 gr. of oil. The crucible has a lid with three openings, one for a thermometer, one for introduction of air under reduced pressure and the third for conducting it out of the crucible.

ECONOMICS

German Oil Policy and the Labor Shortage—Oskar Tokayer, in PETROLEUM PRESS SERVICE, vol. 5 (1938), No. 35, pp. 409-412.

Official German plans for replacing imported oil by domestic products have encountered a number of obstacles, among which is a shortage of skilled and unskilled labor which is being felt in the synthetic oil industry as well as in other industries. The number of men (65,000 to 70,000) required for the actual manufacture of oil from coal is not nearly so impressive as the number required to supply the raw material and other accessories. To supplement the product of existing German oil fields the coal-oil plants must have an annual output of 5,000,000 tons of the synthetic product (the present output being about 850,000 tons). To produce these 5,000,000 tons of oil no less than 22,500,000 tons of coal are needed, or 12 percent of the country's consumption of coal and lignite. This will require 135,000 more coal miners than are now available, and the number of new workers annually entering the coal industry is already a third less than is needed for replacements. Further complicating this labor shortage as affecting the synthetic oil industry are the increased coal requirements of the iron and steel industries, the synthetic rubber industry and a host of other *ersatz* industries upon which has been laid the burden of making the country independent of imported products. All these industries need more workers, and this need cannot be met by shifting labor from one industry to another.

The conclusion appears to be inescapable. Despite every effort on the part of the authorities, Germany's grandiose self-sufficiency program in general and her oil policy in particular are becoming increasingly difficult of accomplishment, even if the financial calculations customary in other countries are disregarded.

(Note: It is possible that the present undoubted labor shortage in Germany will largely disappear when the huge armament program has been accomplished or suspended.—Ed.).

Survey of Crude Oil in Storage, 1936-1937—Report by Petroleum Economics Division of the BUREAU OF MINES, R. I. 3417, September, 1938.

The question of what is a normal stock of crude oil is of great interest to the petroleum trade, particularly when forecasts of demand for oil products are to be made. At the request of the Interstate Oil Compact Commission and with the aid of a congressional appropriation, the Bureau of Mines undertook to make a physical inventory of oil stocks as of June 30th, 1936. The full report of this survey is now published. It was found that at the time of the survey, the minimum working stocks of crude oil required for operation of the industry were approximately 105,000,000 bbl., as follows:

About 11,000,000 bbl. of crude oil representing accumulations on leases to maintain an adequate supply for delivery to gathering lines.

About 43,000,000 bbl. of the 50,000,000 bbl. held by pipeline companies, divided into—

(a) The 21,000,000 bbl. actually contained in gathering and trunk pipelines.

(b) About 12,000,000 bbl. contained in minimum working tanks for main trunk-line operations.

(c) About 10,000,000 bbl. of essential terminal storage out of the 17,000,000 bbl. of tank storage at gathering-line terminals, main-line transshipment points, and main-line terminals.

An average of about 4,000,000 bbl. in transit to domestic refineries by barge or tankship.

Approximately 47,000,000 bbl. at refineries, representing a minimum safety factor of about two weeks' supply.

Considering the characteristics of petroleum operations and the organization of the industry, probably it is necessary to have at least 100,000,000 bbl. of contingent reserves above ground, in addition to the 105,000,000 bbl. of true working stocks, to meet all of the industry's varied needs.

As compared with the normal supply of 205,000,000 bbl. here indicated the above ground supply on June 30th, 1936, was 311,000,000 bbl. of refinable crude oil.

Crude Petroleum and Petroleum Products; A Review of 1937 with Final Statistics for 1936—A. G. White, G. R. Hopkins and H. A. Breaky, in MINERALS YEARBOOK FOR 1938.

In reviewing the events of 1937, the experts of the Bureau of Mines note that virtually every branch of the domestic petroleum industry set new high records. However, the year was marked by many conflicting trends and abnormal features.

On the whole, 1937 was prosperous. The sharp recession in general business activity was reflected to a smaller extent in the oil industry than in most of the other major productive industries. The sudden interruption in the long and steady growth of domestic demand for oil products possibly created more alarm than the facts warranted. Actual demand even at the end of the year, showed no decrease over the previous year except in domestic demand for residual fuel oils.

The domestic situation was partly offset by an unexpectedly large export market. Exports of all oils increased 40,000,000 bbl., or almost 31 percent over 1936.

Increased inventories represented the most disturbing factor at the end of the year. The year ended with stocks of all oils about 45,000,000 bbl. greater than at the first of the year. Most of this increase was unnecessary, although part of it was unavoidable owing to the unexpected and sharp decline in total demand. The net increase of about 16,000,000 bbl. in domestic crude stocks, the result of an increase of 20,000,000 bbl. in the first yalf of the year, and a subsequent decline of 4,000,000 bbl. in the last half, was a major disturbing factor and was closely related to excess refinery runs that helped to produce a net increase of 14,000,000 bbl. in finished-gasoline stocks and a net gain of about 11,000,000 bbl. in stocks of residual fuel oil for the year.

The net increase of 45,000,000 bbl. in stocks of all oils in 1937 represented a 4,000,000 bbl. decrease for California and a 49,000,000 increase for States east of California.

The opinion is expressed that an adequate and prompt reduction of the seasonal accumulation of gasoline stocks is of outstanding importance.

GENERAL

The Diesel in World Transport—Oskar Tokayer, in PETROLEUM PRESS SERVICE, Vol. 5 (1938), No. 41, pp. 481-484.

In mid-1914 LLOYD'S REGISTER listed a mere 297 motorships, with a combined 234,287 gross tons. By the middle of the current year the total had risen to 6,912 vessels, with a total gross tonnage of 15,232,953. Thus in less than a quarter of a century the proportion of motorships in the world's total shipping tonnage has risen from 0.45 to 22.5 percent; and there is no doubt that this proportion will continue to rise year by year, for motorships form a high percentage of the vessels under construction. The total number of vessels building on September 30, amounted to 685, with an aggregate gross tonnage of 2,712,277; of these 433 vessels, with a gross tonnage of 1,752,903—i.e., almost 65 percent of the total—were Diesel driven. The participation of the leading ship-building countries in this total is set out in the following table:—

Motorships Under Construction (September 30, 1938)

	Vessels	Gross Tonnage	Percent of World Tonnage
Great Britain	81	506,203	57.2
Germany	87	249,656	65.1
Holland	88	241,897	98.0
Japan	33	165,812	52.2
Italy	20	151,750	99.0
Sweden	23	115,150	98.5
Denmark	19	111,690	100.0

Although the application of the Diesel to railway traction is virtually a development of the last five years, the number of Diesel railcars in the world is making rapid progress. The inadequacies of the existing statistical material make an exact survey impossible, but the following table gives some idea of the trend of development in the principal countries:

Diesel Traction on the Railways * (Position at January 1, 1938)

	Railcars	Locomotives
Germany	671	1,171
France	662	121
Italy	266	1
Argentina	245	35
United States	39	115
Holland	65	106
Great Britain	27	35

* Based on information given in the "Oil Engine."

At the beginning of the year 1938 there were about 1,700 Diesel locomotives and 3,000 Diesel railcars in use in the world; while in June, 1938, the number of railcars and locomotives was estimated at 5,400.

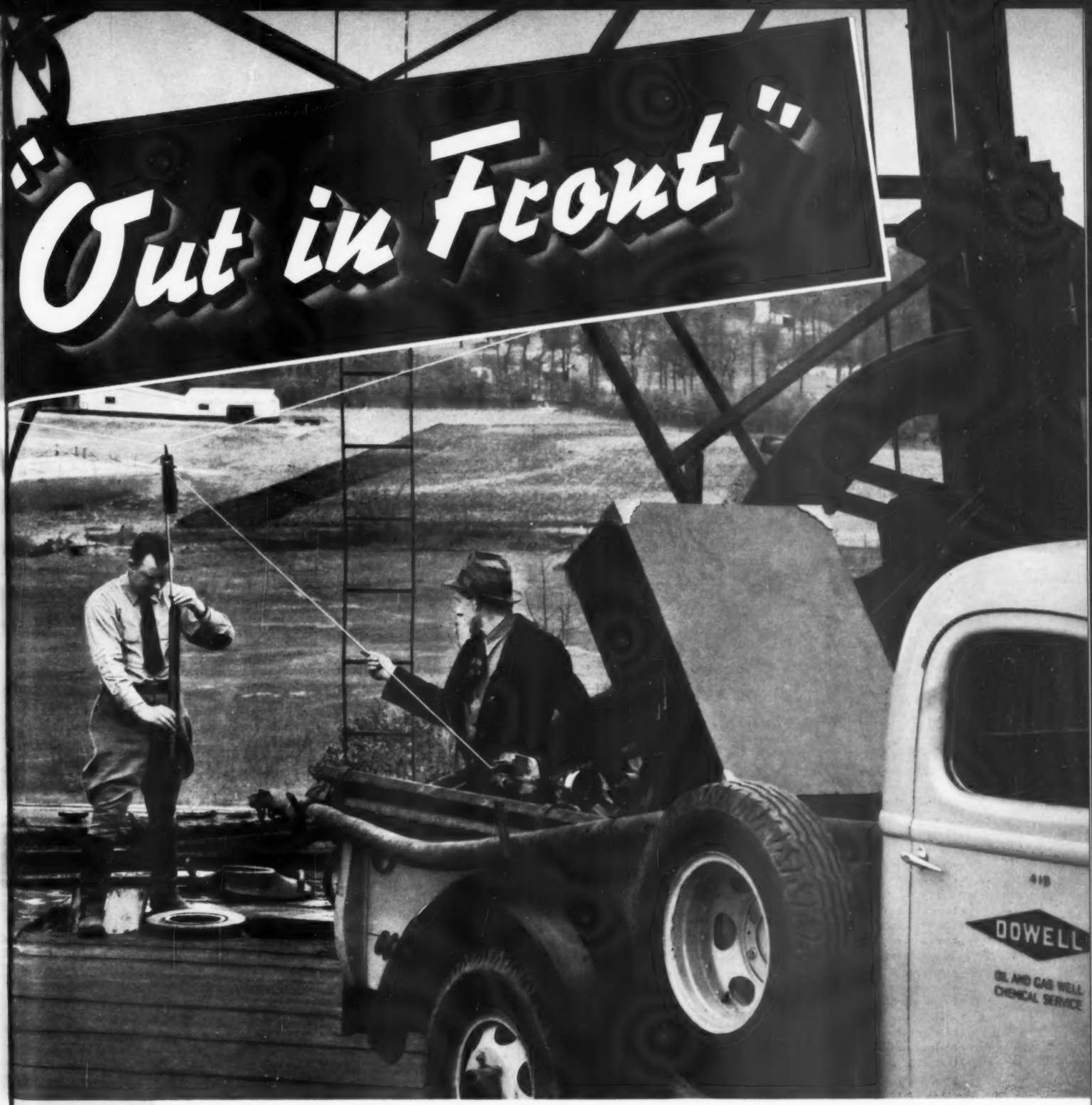
The position occupied by Diesel-engined road vehicles in some of the principal countries is set out in the following table:

Lorries and Buses in Use

	Diesel-engined	Total
Germany	57,410	384,182
Great Britain	20,100*	575,224
France	17,500*	550,000
Italy	5,500	121,459
United States	5,000*	4,362,695

* Estimated.

In the application of the Diesel engine to aviation, the problems encountered are somewhat similar to



OUT IN FRONT . . . with Broader Technique

Acid is only a tool.

In the early days of oil, acid was tried as a tool to increase production—but it failed. It failed because those using it lacked knowledge.

It remained for Dowell to discover the secret—an *Inhibitor* which allowed the acid to do its job without disastrous damage to tubing and equipment.

This same wider knowledge is, today, evident in Dowell's whole service. Dowell has perfected many new materials and many new methods. It knows where and how to use these materials.

Informed oil producers are taking full advantage of Dowell's broader technique. To them, Dowell is far "out in front."

DOWELL

DOWELL INCORPORATED
Subsidiary of THE DOW CHEMICAL COMPANY
Executive Office: MIDLAND, MICHIGAN
General Office: KENNEDY BUILDING, TULSA, OKLA.

OIL AND GAS WELL CHEMICAL SERVICE

those met with in the case of road transport. The Diesel can compete only under special conditions, which cannot always be fulfilled.

Decline in World Motor Vehicle Output—Oskar Tokayer, in PETROLEUM PRESS SERVICE, Vol. 5 (1938), No. 35, pp. 414-415.

The first six months of the year 1938 have witnessed a sharp reaction from the record production of motor vehicles achieved in most of the leading automobile manufacturing countries in 1937. Output of private cars and commercial vehicles during the period January-June amounted to about 2,000,000 units, or about 1,600,000 units fewer than in the corresponding period of 1937. This decline of 45 percent clearly reflects the effe ts of the general recession of business activity on the motor car market.

The world figures are, of course, influenced largely by the precipitous drop of 57 percent in output in the United States, which brought America's share in the world total from over 75 percent to about 60 percent.

The decline during the first half of the year 1938 has brought the volume of output in the American automobile industry to below the 1934 figure. Production in June was actually smaller than n June, 1932, the worst year of the depression.

In the Canadian motor manufacturing industry, which is closely allied to that of America, a decline of over 20 percent was recorded compared with the previous year. In Europe, the only country to suffer a marked contraction was Great Britain:—

Motor Vehicle Production

	January-June 1938	1937	Percentage Change
U. S. A.	1,203,874	2,790,420	—56.8
Canada	102,158	128,371	—20.4
Great Britain	246,056	274,381	—10.3
Germany	176,736	157,290	+12.4
France	113,000*	113,000	—
Russia	108,500*	92,000	+17.9
Italy	34,200	32,300	+ 5.9

* Estimated.

With a decline of 28,325 units, British production of motor vehicles is now below the 1936 figures. In France, which had not shared in the general increase last year, output was maintained at its former level; it might even have been increased had it not been for the effects of the 40-hr. week and other economic measures which militated against an expansion in operations.

The increase of 19,446 units in German output reflects the continuation of the policy of fostering the expansion of goods transport by road. While the number of private cars manufactured rose by 10.9 percent, production of commercial vehicles advanced by 19.5 percent, while tractor output, which is not included in the above figures increased by nearly 60 percent.

Italian motor production has also made headway, albeit at a somewhat slower pace. The same applies to Russia, where output, at nearly 18 percent more than 1937, compared with a 39.4 percent improvement in 1937.

Sub-Surface Sampling—D. L. Katz, before AMERICAN PETROLEUM INSTITUTE, Chicago meeting, November, 1938.

This paper is an abstract of the Report of the Subcommittee on Fundamentals of Obtaining, Transporting, and Analyzing Sub-surface Samples of Crude Oil prepared for the Topical Committee on Production Technology. It discusses the fundamental principles underlying the behavior of complex hydrocarbon systems for the purpose of providing a basis for critical review of the methods of obtaining, transporting, and analyzing sub-surface samples of crude oil. Recommended terminology and methods of reporting data on sub-surface samples are included.

The greatest contribution which sub-surface-sample work has made to the production industry is the development of our concepts of the behavior of oil and gas in the reservoir. Not until sub-surface samples were obtained did we have a clear idea of the phase relations in the sand—which is necessary in order to make intelligent decisions on many daily production problems.

Sub-surface-sample data make possible an alternate method of estimating the oil in place in a constant-volume pool, without knowledge of sand extent. A complete production history of the pool with sub-surface pressures is the auxiliary information needed.

Fractional analyses of sub-surface samples and equilibrium constants are used to predict surface separations of oil and gas as to gas-oil ratio and natural-gasoline content of the gas. Stage separation and natural-gasoline reserves now are understood more completely.

Better identification of horizons is permitted by the combined use of equilibrium data and sub-surface-sample analyses. Because of the high concentration of the more volatile constituents in high-bubble-point-pressure samples, an added criterion for identifying a reservoir liquid is available. Sub-surface-sample analyses and equilibrium data assist in identifying gas zones as being the equilibrium phase for a reservoir oil or not of the proper composition to be the equilibrium phase.

Bulk Production of Hydrogen—David Brownlie, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 30 (1938), No. 10, pp. 1139-1146.

Because of the vast developments in synthetic nitrogen products in hydrogenation processes, and in the production of organic compounds, hydrogen has become one of the world's most important raw products, and the limit of its use in industry does not yet appear to be in sight.

This paper lists 25 chemical reactions and processes by which hydrogen may be obtained. Most of these reactions and processes are at present of no practical importance for the bulk production of hydrogen, and only three account for almost the entire world commercial production of hydrogen. These are: (a) total gasification of coal, coke and lignite by the water-gas and producer gas processes, which at present accounts for about 55 percent of the total; (b) separation from coke-oven gas by the Linde-Claude and similar low-temperature liquefaction plants, 26 percent; and (c) electrolysis of water, 16 percent, leaving three percent for all other purposes.

One of these minor methods is the production of hydrogen from the action of superheated steam on hydrocarbon gases, chiefly methane. This process is used in the German synthetic petroleum works that operate by the Fischer-Tropsch process. The same process is applied at the two large oil hydrogenation plants of the Standard Oil Company at Bayway, N. J., and Baton Rouge, La.; where natural gas and refinery gases are used as the starting material.

BOOKS

Sea Transport and Measurement of Petroleum Products, by Captain P. Jansen and H. Hyams, A. M. Inst. P. T.—England: T. L. AINSLEY LTD.; 9 in. by 6 in., 185 pg. with 12 diagrams; net price: 12 s. 6d. (about $3.25).

Credit is due to the authors for producing a thoroughly readable and useful manual. As indicated by the title, the book is divided into parts—one on oil cargo handling and the other on measurement.

In Part I, Captain Jansen has evidently revised and brought up-to-date his book of about two decades ago on the same subject. Being in charge of Anglo-Saxon Petroleum Company Ltd.'s nautical department he is qualified to write on such a subject.

The task of incorporating all the desired information into the 55 pages of Part I is obviously a difficult one, but the chapters dealing with cleaning, gas-freeing and fire prevention (as in the case of two other British tanker manuals) give rise to the question as to whether European operators are keeping abreast of American developments along these lines through the medium of the trade press. No mention is made of the Butterworth system of tank-cleaning (barrel and caustic soda unit is described) nor is reference made to the inert gas system of fire prevention—although three lines are devoted to its use when draining tanks of casinghead gasoline.

When serious oil tanker accidents focused attention on the problem of safe operation of tankships five years ago, Neil B. Musser analyzed the various operations of oil tankers and demonstrated that at no time does the use of steam in the tanks reduce the hazards encountered while he also showed that the use of the conventional type of steam-smothering system is apt to result in even greater hazards than would otherwise exist. He discussed other important disadvantages of using steam in the tanks and made a suggestion as to how the cost of the steam-smothering system could be saved by connecting the master valve to the after end of a deck piping system, designed primarily for distributing inert gas to the tanks and for venting the tanks while loading. Addition of inert gas to the oil vapors to the exclusion of air prevents the formation of explosive mixtures in the tanks during loading and discharge, as well as during voyages, greatly increases the safety factor. None of these developments are mentioned.

Judging by this latest book, hydraulic tank-cleaning and the inert gas system—standard practice with major American tanker fleets—appear to be virtually unknown to European operators.

Part II deals with matters relating to cargo loading and discharge, and the checking of ship's quantities against shore quantities. Also included are simple methods of oil testing for purposes of calculation, and complete tables are given for converting tonnages into and from volume measurements.

Mr. Hyams is eminently qualified to write Part II, being assistant to the chief chemist of Asiatic Petroleum Co. Ltd., as well as being a member of the Institute of Petroleum's sub-committee on standardization and co-author of the Institute's book "Measurement of Oil in Bulk." This, the larger portion of the book, is vast in its scope and the mass of conversions and other tabular matter speak for themselves. The information therein should be of value to those who wish to avoid discrepancies between ship and shore cargo quantities, due to differences of temperature and incorrect method of measurement and computation, and an understanding of these matters should reduce the likelihood of disputes between carriers and shippers which might arise from incorrect measurements and calculations.

Oil Well Surveys, Their Necessity and Application—Published 1938 by LANE-WELLS CO., Los Angeles, Calif. 19 pages.

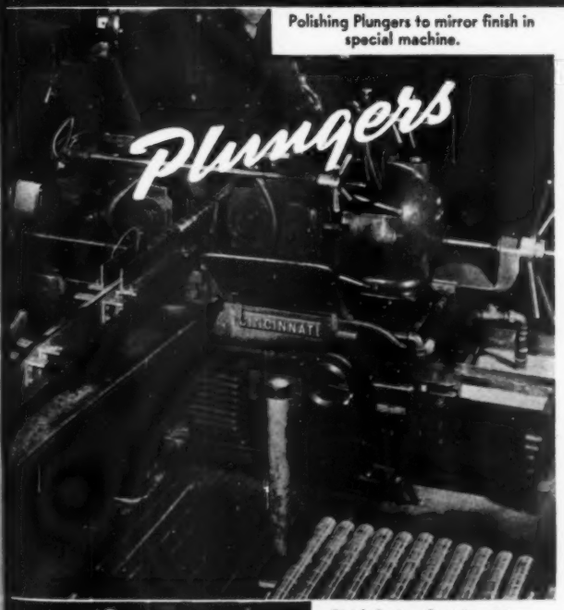
This bulletin stresses the importance and economical advantage of drilling oil wells vertically and straight. It is essential for the operator to know where the bottom of his hole is at all times, and whether it is going in the proper direction; he must therefore control the inclination and the direction of the hole.

The bulletin explains in detail what may and does happen when the drill is allowed to drift by itself; it describes the instruments that have been invented for surveying oil wells, and gives examples of how they are used.

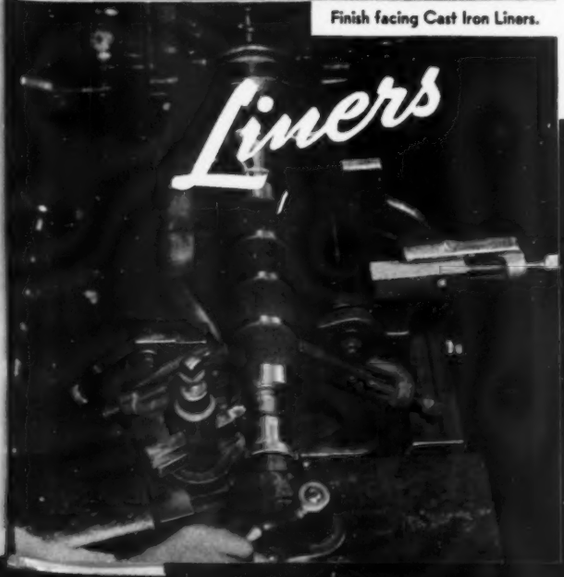
Finishing seat faces in vertical surface grinder.

Lapping Balls individually to both sides of their mating seats in special patented machine of Axelson design.

MORE LIFE IN AXELSON PUMPS



Polishing Plungers to mirror finish in special machine.



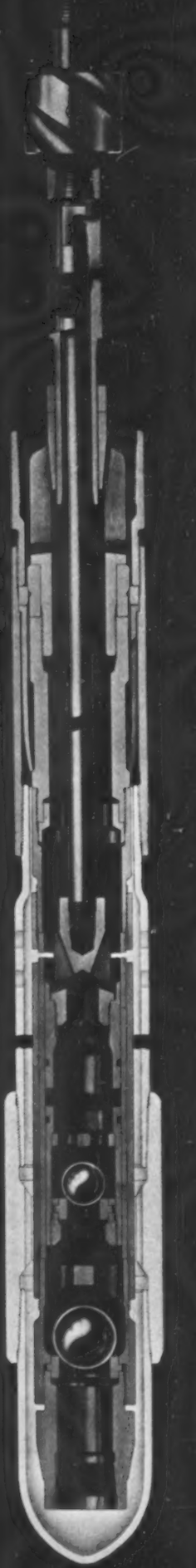
Finish facing Cast Iron Liners.

Axelson deep well plunger pumps plug along night and day for days—months—years, undergoing millions of strokes and lifting thousands of barrels of oil with the constancy of the sunrise.

Even in wells with bad conditions—salts, sands, sulphides, emulsions, gas, water, unusual depths — Axelson Pumps are dependable because Axelson has studied these conditions and built special pumps to meet those conditions.

It's the "know how" that makes Axelson Pumps the first—the only—choice of every production man who wants oil at the surface at the lowest overall cost.

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY



Axelson R.S.L. Super Service Pump.

AXELSON

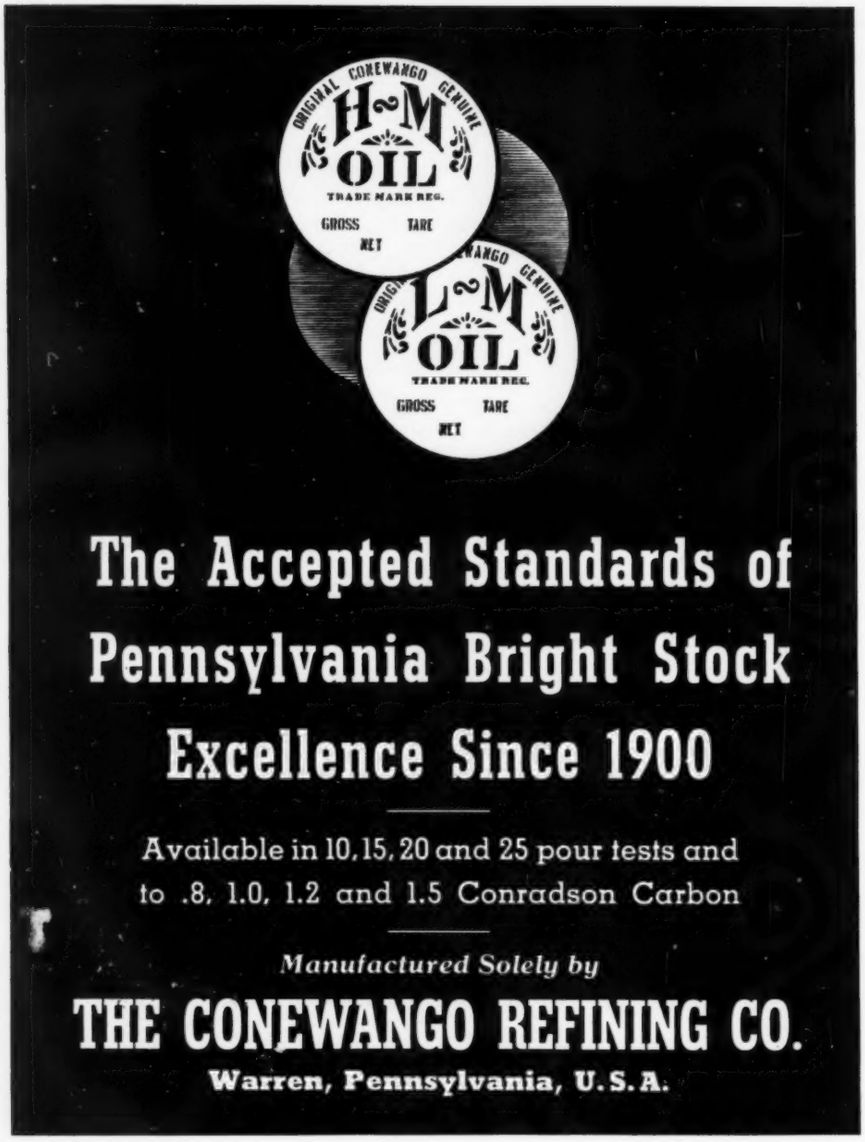
DEEP WELL PLUNGER PUMPS · SUCKER RODS

AXELSON MANUFACTURING COMPANY — P. O. Box 98, Vernon Station, Los Angeles • St. Louis • 50 Church Street, New York • Tulsa

Mid-Continent and Eastern Distributor: Frick-Reid Supply Corporation

Rocky Mountain Distributor: Great Northern Tool & Supply Company

Foreign Representatives: "COSMOS" Soc. in Nume Colectiv, Bucharest, Roumania • *Direct Factory Representative,* Bucharest, Roumania • Industrial Agencies, Ltd., San Fernando, Trinidad, British West Indies *Factory Representative,* Maracaibo, Venezuela • Armco International Corp., Buenos Aires, Argentina



OIL DISTRIBUTION

The Great Western Railway Company's South Wales Docks at CARDIFF, SWANSEA, NEWPORT, BARRY, PORT TALBOT and PENARTH (Harbour) are excellent terminals for oil distribution.

SWANSEA DOCKS is one of the greatest oil ports in Great Britain.
Important oil depots have also been established at CARDIFF and at PENARTH (Harbour).

SITES FOR NEW DEPOTS ARE AVAILABLE

For information apply to the respective Dock Managers or to :—

W. J. THOMAS,
Chief Docks Manager,
Great Western Railway,
CARDIFF

Paddington Stn., London, W.2.

OIL TANKERS AT SWANSEA DOCKS

JAMES MILNE, *General Manager,*

BASRAH
Concession Ratified

By A. E. Mulford

PROVIDING that export of oil must begin after seven and a half years from the date of ratification, the agreement awarding the southern Iraq oil concession to Basrah Petroleum Company, Ltd. (associated with Iraq Petroleum Company, Ltd.) has been approved by the Iraqi parliament at Baghdad. It consists of 48 articles, and was signed by Ibrahim Kamal, Minister of Finance and acting Minister of Economics and Communications, on behalf of the Iraq government, and John Skliros, managing director of Iraq Petroleum Company, Ltd., for the concessionary group.

The period of the concession is 75 yr. The area is specified as all territory in Iraq not given out under the concessions previously granted to Iraq Petroleum Co., Ltd., B.O.D. Ltd., and Anglo Iranian Oil Co., Ltd. (Khanaqin).

The concession requires the company, within eight months of the agreement coming into force, to embark on a detailed geological survey on at least three different areas inside the concession, and within three years to start drilling.

From that time drilling operations must be carried out at the rate of 12,000 ft. a year. Within a year from striking oil, the company will be called upon to increase its drilling rate to 20,000 ft. annually until it begins to export its oil regularly. Such export must begin seven and a half years from the date of the agreement, the minimum rate being 1,000,000 tons per year, and is to be made either through an independent pipeline running to seaboard (Gulf of Iran or Mediterranean Sea) or by other means of transport.

Beginning with January 1st, 1939, Basrah will pay the Iraq government dead rent at the rate of £200,000 in gold a year until the company start the regular export of oil. Royalties have been stipulated at four (gold) shillings per ton with a minimum of £200,000.

Under the agreement, the Iraq government is entitled to 20 percent of the oil production free, on which no royalty will be paid.

During the exploratory period, the company will also pay the Iraq government £1,000 in gold annually and, on production, £15,000 gold per 1,000,000 tons produced for the first 4,000,000 tons and £20,000 gold for every subsequent 1,000,000 tons, thus exempting the company from all taxation and customs duty.

(Continued on page 80)

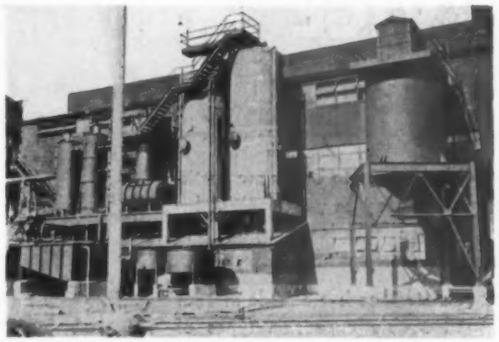
CHEMICO ACID SLUDGE CONVERSION

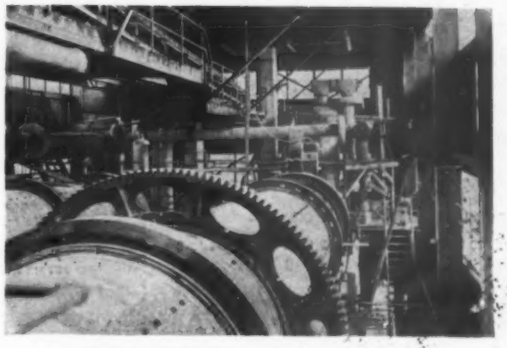
the process which provides a superior sulphuric acid supply, minimizes costs of acid treating operations, and makes acid sludge truly valuable

THIS process decomposes the acid sludge by heat, purifies the extracted gases, adds to them by the burning of hydrogen-sulphide or sulphur, re-purifies and dries the combined gases, converts the sulphur-dioxide content into sulphur-trioxide and absorbs the latter into fresh acid.

The whole procedure is highly efficient and economical for these five good reasons:

1. The finished acid is clear, virtually water white, contains no suspended hydrocarbons, etc., and requires no further cleansing or concentration.
2. High-strength acid with maximum recovery is produced even from sludges that are unsuitable for economical treatment in any other way. Simple dilution makes acid of any lower strength quickly available. In contrast, acid recovered by separation is weak, dirty and can be concentrated only with lower yields and strengths, due to the tendency of the concentrating process to break down some of the acid into carbon-dioxide, sulphur-dioxide and water.
3. The acid supply is self-sustained and independent. By adding in the process a little sulphur-dioxide from the combustion of hydrogen-sulphide or sulphur, as make-up for the slight loss in the acid cycle, an ample, dependable and highly satisfactory acid supply is always available for all acid-treating operations.
4. The sludge is completely useful. Approximately 90 per cent of the acid content goes back into the regenerated acid, and the only residue is recovered oil and petroleum coke. The latter has a fuel value equivalent to its full heat content, and contains so little sulphur that it may be profitably burned without objection even in congested districts.
5. Sludge disposal problems are eliminated. No labor expense is incurred for non-productive sludge handling, no sludge dumps or temporary waste storage facilities are required, and there is no pollution of nearby water or air, with the attendant risk of bad public relations.





CHEMICO SLUDGE CONVERSION PLANT

CHEMICO Sludge Conversion Plants are a proven essential to the large refinery, and their performance is assured by indisputable records. Each installation is engineered to the individual needs and acceptance is asked only after every contract obligation has been met.

If your daily sulphuric acid requirement exceeds 20 tons, let us submit you some impressive facts and figures on the performance of the CHEMICO Sludge Conversion Process. For smaller requirements not justifying a complete sludge conversion plant, proven types of CHEMICO separators and acid concentrators are the best available equipment.

CHEMICAL CONSTRUCTION CORPORATION

MAIN OFFICES: 30 ROCKEFELLER PLAZA, NEW YORK

European Representatives: Cyanamid Products, Ltd., 14 Finsbury Circus, E.C.2, London, England

CHEMICO PLANTS are PROFITABLE INVESTMENTS

Airetool

SUPER POWER CLEANERS

are built to give SERVICE on the toughest job . . .

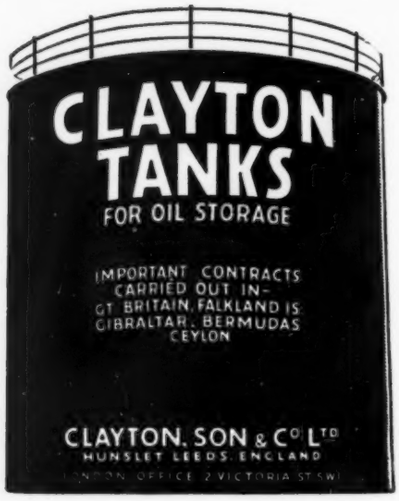
Airetool has proven to be the most satisfactory tube cleaner as yet developed—having abundant speed, power, long life and simplicity of construction.

Airetool cutter heads are made in both single and double expansion types of different designs to meet every coke condition. Airetool keeps plants operating at highest efficiency, with fewer tube replacements and is your guard against untimely breakdowns — *of great importance to isolated refineries.*

WRITE FOR BULLETIN No. 12
it has valuable information about tube cleaners that are made to solve your tube cleaning problems.

MIDGET CLEANER
Airetool Midget Cleaners make quick work of tedious small tube cleaning jobs

THE AIRETOOL MFG. CO.
SPRINGFIELD, OHIO



RIGHT ON THE BOARDWALK
HOTEL CHELSEA
For Recreation Or Relaxation
Choose the Chelsea
FROM $8 WITH MEALS & BATH
$3 ROOM ONLY & BATH
Here you will find everything to further your comfort and enjoyment—outside ocean-view rooms . . . sun deck . . . beautiful dining room at the ocean's edge . . . superb cuisine . . . varied sports . . . and entertainment. You'll like your fellow guests . . . and the delightfully friendly atmosphere of The Chelsea.
SPECIAL WEEKLY RATES
ATLANTIC CITY

Second Kuweit Producer

ANOTHER strong producer has been obtained in Arabia by Kuweit Petroleum Company Ltd. (Gulf Oil and Anglo-Iranian). It will be remembered that the first test well, Bahrah No. 1 north of Kuweit Bay, was a dry hole, while Burghan No. 1, south of the bay, produced 4,400 bbl. daily upon initial test flows. Burghan No. 2 has now been completed about two miles due east of No. 1 at a depth of 3,772 ft. with satisfactory potential output. It is undecided whether the company will drill further wells to the proven horizon in order to define the limits of production, or whether it will first deepen No. 2 well to the Bahrein pay. Indications are that the Burghan structure may prove to be quite prolific—the high gas ratio indicates that drilling is still close to the crest, and recent cores have shown a dip of seven degrees—and while it is only 30 to 40 mi. in length and shorter than that at Kirkuk, in Iraq, it is evidently much wider.

Czechoslovakia's Oil Demand

CONSUMPTION of mineral oils in Czechoslovakia is expected to decrease 30 percent as a result of the recent territorial cessions to Germany, Poland, and Hungary, according to the American Commercial Attache at Prague.

The heaviest decrease of 35 percent is anticipated in consumption of lubricating oils, while sales of gasoline may decrease 33 to 35 percent. Estimates point to a sales decrease of 20 to 25 percent in kerosene purchases.

Czechoslovakian Oil Consumption

	1936	1937
	Barrels	
Gasoline	1,691,500	1,819,000
Kerosene	647,125	647,125
Gas oil	217,500	275,500
Lubricating oils	318,500	378,000

Within the former boundaries of Czechoslovakia their were 13 refineries having an annual capacity of 3,570,000 bbl. of which two were ceded to Germany, one to Poland, and one to Hungary. Loss of the ceded refineries reduces the total capacity by about 22 percent to 2,700,000 bbl. The present capacity is sufficient because they have been operating below capacity and the new government refinery started production in October, 1938.

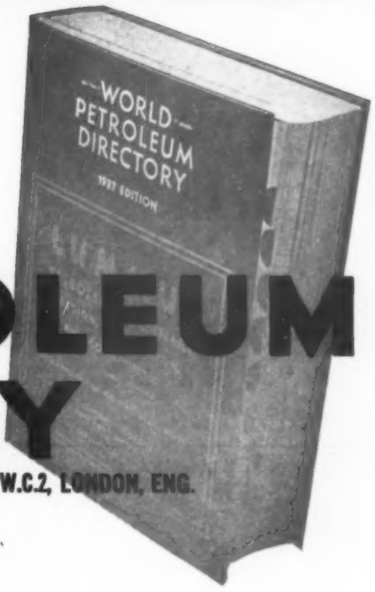
French Tanker Subsidy

A DECREE law under which owners and builders of oil tankers will be given a subsidy depending on the age and capacity of the ship has been put into effect by the French government. The subsidies to existing vessels will begin to be paid in 1939, but only when the average freight rate on black oils between Gulf ports and European ports is less than 13.6.

Don't let the days fly by—

Order Your Copy now

$10.00 per Copy



WORLD PETROLEUM DIRECTORY

95 RIVER STREET, HOBOKEN, N. J. • 412 W. 6th ST., LOS ANGELES • 3 SAVOY PL., W.C.2, LONDON, ENG.

Keep Informed on international petroleum matters . . . Subscribe to WORLD PETROLEUM $5.00 for a full year's subscription . . . 13 copies

NEW YORK
56 West 45th St.

LONDON
3, Savoy Pl.

(Continued from page 76)

Basrah Petroleum Company will in addition, pay the Iraq government £3,000 per annum for the training of Iraqis in England, the courses for study to be decided upon by separate agreement.

Basrah Petroleum Company has been granted permission to set up its own telegraph, telephone and wireless installations for use solely in connection with its pipeline. similar to the one granted to the I. P. C.

During the first 30 yr., Basrah Petroleum Company has the right of notifying the cancellation of the agreement at three months' notice. The Iraq government may appoint a director to the board of the company, who will enjoy the rights, privileges and salary of other directors.

Basrah Petroleum Company is described in the agreement as a British company, registered in Great Britain, where its head office must be situated, and its executive head must be a British subject.

While Basrah Petroleum Co., Ltd., is made up of the same interests as the Iraq Petroleum Co., Ltd., with ownership divided in the same proportions it is not a subsidiary of the I.P.C. but an entirely independent operation.

CANADA

PRODUCTION of crude petroleum and natural gasoline in Canada in 1938 set up a new high record at 6,870,000 bbl. worth $11,514,000, according to a report of the Dominion Bureau of Statistics at Ottawa. The previous high mark of 2,943,750 bbl. valued at $5,399,353 was reached in 1937. The Turner Valley field in Alberta continued to be the focal point of interest in the Canadian petroleum industry. During 1938, to the end of November, 38 new wells were drilled into production and, at the end of this period, drilling operations were in progress on 15 other wells. As the market for petroleum products from Turner Valley oil is at present confined to the three Prairie Provinces, the output is on a proration basis, the allowable production being governed by the demand. Production in this field reached its peak in September when 863,229 bbl. were produced; in the following month the output was lower at 663,578 bbl. With the seasonal decline in demand the November and December outputs were considerably reduced. On December 5th the Alberta Oil and Gas Resources Commissior set the daily allowable output for all Turner Valley wells, exceeding a depth of 3,500 ft. at 12,500 bbl.

An advance of three percent was recorded in the production of natural gas in Canada during 1938 compared with the preceding year; the totals were 33,351,000,000 cu. ft. and 32,380,991,000 cu. ft.

LEACH EXCHANGERS
for
High Temperatures
High Pressures

Fracto Control

High Heat Transfer
Low Vapor Pressure Drop
Long Tube Life
Easy Cleanability

Leach Exchangers are fully protected by U. S. and foreign patents

C. H. LEACH CO.
117 Liberty St. New York

RENOLD
MARK 3

OIL WELL CHAIN

Designed and made to A. P. I. specification by the world's leading driving chain makers.

Send for leaflet No. 216/32

THE RENOLD & COVENTRY CHAIN CO., Ltd.
MANCHESTER, ENGLAND
Agents throughout the world

Prestige

The Blackstone is world-famous as an address of distinction in Chicago. Here graceful living is enjoyed by the discriminating traveler.

A. S. Kirkeby, Managing Director

The Blackstone
MICHIGAN AVENUE - CHICAGO